Manitoba
Energy and Mines
Geological Services

Geological Report GR83-1B

Geology of the Knee Lake-Gods Lake Area

By H.P. Gilbert

Winnipeg 1985

Energy and Mines

Hon. Wilson D. Parasiuk
Minister

Charles Kang
Acting Deputy Minister

Geological Services

W. David McRitchie
Director

TABLE OF CONTENTS

Page

INTRODUCTION

Location and access 1
Physical features and drainage 1
Previous work 1
Present work 1
Acknowledgements 3

GENERAL GEOLOGY

Regional setting 4
Summary of geology and geological history 4

HAYES RIVER GROUP 7
SOUTHERN KNEE LAKE AREA 7
Metamorphosed mafic volcanic and related subvolcanic rocks; minor ultramafic rocks; minor sedimentary rocks (1) 7
Serpentinized peridotite ($1a_2$) 7
Basalt, minor andesite, related sills, minor basic tuff (1b); porphyritic andesite and basalt, minor dacite and related sills (1c); megaphyric andesite, basalt and related minor intrusions (1d) 7
Equigranular gabbro ($1e_1$); porphyritic gabbro ($1e_2$); mesocratic porphyry, quartz gabbro, granophyre ($1e_4$) 9
Mafic to intermediate pyroclastic rocks, minor greywacke, argillite and basalt (1f) 9
Epidotized basalt, epidote amphibolite (1g); amphibolite, amphibolitic schist, minor feldspathic greywacke (1h) 10
Amphibolite 10
Feldspathic greywacke 10
Metamorphosed felsic volcanic, subvolcanic and related sedimentary rocks (2) 10
Porphyritic rhyolite and dacite, minor related intrusions, pyroclastic rocks and minor mafic flows ($2a_1$); quartz-feldspar porphyry (2d) 11
Felsic to intermediate volcanic fragmental rocks, minor rhyolite and sedimentary rocks (2b) 13
Iron formation (2c) 13
Metamorphosed volcanogenic sedimentary rocks and minor volcanic rocks (3) 15
Tuffaceous greywacke, minor graphitic argillite, tuffisite and pebble conglomerate (3b) 15
Feldspathic greywacke, minor argillite (3f) 15

MAGILL LAKE AREA 16
Metamorphosed mafic volcanic and related subvolcanic rocks; minor ultramafic rocks; minor sedimentary rocks (1) 16
Epidotized basalt, epidote amphibolite (1g); amphibolite, amphibolitic schist, minor feldspathic greywacke (1h) 16

GODS LAKE AREA 18
Metamorphosed mafic volcanic and related subvolcanic rocks; minor ultramafic rocks; minor sedimentary rocks (1) 18
Basalt, minor andesite, related sills, minor basic tuff (1b); porphyritic andesite and basalt, minor dacite and related sills (1c); megaphyric andesite, basalt and related minor intrusions (1d) 18
Equigranular gabbro ($1e_1$); porphyritic gabbro ($1e_2$); mesocratic porphyry, quartz gabbro, granophyre ($1e_4$) 20
Mafic to intermediate pyroclastic rocks, minor greywacke, argillite and basalt (1f) 20
Epidotized basalt, epidote amphibolite (1g); amphibolite, amphibolitic schist, minor feldspathic greywacke (1h) 20
Metamorphosed felsic volcanic, subvolcanic and related sedimentary rocks (2) 21
Felsic to intermediate volcanic fragmental rocks, minor rhyolite and sedimentary rocks (2b) 21
Iron formation (2c) 21
Metamorphosed volcanogenic sedimentary rocks and minor volcanic rocks (3) 24
Greywacke, tuff, minor intermediate and mafic flows and volcanic fragmental rocks (3a) 24
Greywacke 24
Volcanic fragmental rocks 24
Intermediate and mafic flows 24
Zones of shearing and mineralization 25
Feldspathic greywacke, minor pebble conglomerate, siltstone, chert and tuff (3e) 25
Feldspathic greywacke, minor argillite (3f) 25

BAYLY LAKE COMPLEX 29
Metamorphosed intrusive rocks of mainly tonalitic composition; minor granodiorite and gabbro (4) 29
Brown Lake-western Gods Lake granitoid complex 29
Gneissoid tonalite, quartz diorite; granodiorite and granite; minor pegmatite, aplite and diorite(4a); gneissoid tonalite (4b); granodioritic augen-gneiss (4e); hybrid rocks derived from units, 1, 2, and 4 (4g); amphibolite (4j) 29
Northeastern Gods Lake-northern Knee Lake granitoid complex 30
Gneissoid tonalite, quartz diorite; granodiorite and granite; minor pegmatite, aplite and diorite (4a); gneissoid tonalite (4b); porphyritic tonalite and minor porphyritic granodiorite (4c); granodioritic augen-gneiss (4e); hybrid rocks derived from units 1, 2 and 4 (4g) 30
Intrusive breccia (4d) 31
Diabase, gabbro (4h); lamprophyre (4i); lamprophyre, diabase (7h) 32

Page

Gneisses and gneissoid rocks of mainly tonalitic composition; minor gabbro, hornblendite, clinopyroxenite and amphibolite (6) 34
Michikinabish Lake-Brown Lake gneiss complex 34
Layered tonalitic to granodioritic gneiss with concordant amphibolite layers (6a) 34
Amphibolite (6b) 35
Protomylonitic quartz monzonite, dioritic gneiss (6d) 35
Pegmatite (6e) 37
Metamorphosed intrusive rocks of mainly granodioritic composition; granite and tonalite; minor syenite (7) 37
Tonalite (7a); tonalite, granodiorite and porphyritic granodiorite (7b) 37
Elk Island pluton 38
Bayly Bay pluton 40
Gods River pluton 40
Seller Lake pluton 41
Quartz-feldspar porphyry, feldspar porphyry (4f); quartz-feldspar porphyry (7g) 41
Mode of emplacement of granitoid complexes (4, 6) and plutons (7) 42

OXFORD LAKE GROUP 43
SOUTHERN KNEE LAKE-MAGILL LAKE AREA 43
Metamorphosed porphyritic volcanic rocks and related sedimentary rocks (8) 43
Massive and pillowed shoshonite (8b$_2$); massive andesite (8c$_1$); pillowed andesite (8c$_2$) 43
Volcanic fragmental rocks and conglomerate with porphyritic, felsic to intermediate and minor mafic fragments, minor tuff and wacke (8e) 43
Feldspathic greywacke, siltstone, argillite and minor chert (8g) 46
Tuff and lapilli-tuff (8h) 46
Porphyritic diabase, gabbro (8i) 48
Depositional environment of the volcanic complex (8) 51
Regional variations in pyroclastic textures within the volcanic complex (8) 51
Structure and stratigraphic relationships of the volcanic complex (8) 52
Metaconglomerate; minor metagreywacke (9) 52
Polygenic conglomerate, minor pebbly greywacke and greywacke (9b) 52
Polymictic conglomerate with volcanic and sedimentary clasts (9c) 55

GODS LAKE AREA 55
Metaconglomerate; minor metagreywacke (9) 55
Polymictic volcanogenic conglomerate (9a) 55
Polygenic conglomerate, minor pebbly greywacke and greywacke (9b) 55
Provenance of the Oxford Lake Group conglomerate (9) 57

SOUTHERN KNEE LAKE-MAGILL LAKE AREA

Metagreywacke, meta-arenite; minor metapelite, amphibolite, paragneiss (10) 57
Feldspathic greywacke, minor pebbly greywacke, lithic wacke, argillite and iron formation (10a); arenite, arkosic wacke (10b); garnet-, andalusite-, staurolite- and cordierite-bearing schists and gneisses (10f); iron formation (10g) 57
Amphibolite (10d) 59

POST-OXFORD LAKE GROUP INTRUSIVE ROCKS 61
Metagranodiorite (11) 61
Granodiorite, porphyritic granodiorite and granite (11a); pegmatite (11b) 61
Magill Lake pluton 61
Minor intrusions 61
Metagabbro and metadiabase (12) 61
Porphyritic diabase (12b) 61
Gabbro and diabase (13) 63
Diabase, porphyritic diabase (13c) 63

METAMORPHIC HISTORY 64
METAMORPHIC FACIES 66

STRUCTURAL GEOLOGY 68

REFERENCES 71

BIBLIOGRAPHY OF OTHER PUBLICATIONS RELATING TO THE GREENSTONE PROJECT 73

APPENDIX A: Chemical analyses of felsic volcanic rocks (2a$_1$) at southern Knee Lake 75
APPENDIX B: Chemical analyses of rocks of the lower Oxford Lake Group volcanic complex (8) at southern Knee Lake and the diabase sill south of Michikanes Lake 76

TABLES

Page

Table 1: Geological maps of the Knee Lake-Gods Lake area. 2
Table 2: Isotopic ages from the Greenstone Project area. 5
Table 3: Table of Formations, Greenstone Project area. 6
Table 4: Phases of flows and intrusive rocks of unit 2a, at southern Knee Lake. 12
Table 5: Clast types of intrusive breccia (4d). 33
Table 6: Plutonic and tectonic histories of the granitoid complex (4) at northeastern Gods Lake. 34
Table 7: Tectonic, metamorphic and plutonic histories of the Michikinabish Lake-Brown Lake gneiss complex (6). 36
Table 8: Chemical analyses of tonalite (6a) and derived cataclasite (6d) at Magill Creek. 37
Table 9: Phases of granitoid rocks of the Elk Island pluton. 39
Table 10: Clast types in volcanic fragmental rocks (8e) at southern Knee Lake. 45
Table 11: Stratigraphic sections at the south and north margins of the volcanic complex (8) at southern Knee Lake. 53
Table 12: Clast types in conglomerate (9b) — (i) east of Magill Lake, and (ii) north of Jowsey Island, Gods Lake. 54
Table 13: Clast types in conglomerate (9c) at Michikanes Lake and the southwest part of southern Knee Lake. 55
Table 14: Tectonic and metamorphic histories of the Hayes River and Oxford Lake Groups. 65
Table 15: Tectonic stages of M_2 porphyroblasts in feldspathic greywacke and schist (10a, 10f). 66

FIGURES

Figure 1: Greenstone Project area showing NTS map sheets. 2
Figure 2: Distribution of supracrustal rocks in the northern Superior Province and location of the Greenstone Project area. 3
Figure 3: Distribution of the Hayes River and Oxford Lake Groups and the Bayly Lake Complex. 28
Figure 4a: Potassium feldspar-quartz-plagioclase modal analyses of gneissoid rocks of units 4a, 4b, 6a and 6d. 29
Figure 4b: Classification of granitoid rocks. 29
Figure 5: Potassium feldspar-quartz-plagioclase modal analyses of rocks in the northeastern Gods Lake-northern Knee Lake gneissoid complex (4a, b, c). 31
Figure 6: Subareas of the Elk Island pluton. 40
Figure 7: Potassium feldspar-quartz-plagioclase modal analyses of the Elk Island pluton (7a, b, i). 40
Figure 8: Potassium feldspar-quartz-plagioclase modal analyses of the Bayly Bay, Gods River and Seller Lake plutons (7a, b, c). 41
Figure 9: Potassium feldspar-quartz-plagioclase normative analyses of quartz-feldspar porphyries (7g). 41
Figure 10: Minor structures and distribution of lithologies within the lower Oxford Lake Group volcanic complex (8) at southern Knee Lake. In pocket
Figure 11: Regional variation of matrix percentage of pyroclastic breccia (8e) at southern Knee Lake. In pocket
Figure 12: Regional variation of maximum clast size of pyroclastic breccia (8e) at southern Knee Lake. In pocket
Figure 13: Clast shape and degree of sorting of pyroclastic breccia (8e) at southern Knee Lake. In pocket
Figure 14: Potassium feldspar-quartz-plagioclase analyses of granitoid clasts in conglomerate (9b). 57
Figure 15: Feldspar-quartz-matrix ternary plot of analyses of sedimentary rocks (10a). 57
Figure 16: Garnetiferous amphibolite (10d) — folded foliation with later weak axial-planar foliation. 60
Figure 17: Potassium feldspar-quartz-plagioclase modal analyses of the Magill Lake pluton (11). 61
Figure 18: Stereographic projections of structural elements. In pocket
Figure 19: Structural domains in the Knee Lake-Gods Lake area. 69
Figure 20: Bedding and regional foliation in subdomains GVa, GVb and GVc, northern Gods Lake. 70

STEREOGRAPHIC PROJECTIONS (Figure 18)

Projection 1: F_3 linear structures in domain KI
Projection 2: F_3 fold axes in domain KI
Projection 3: F_3 axial planes in domain KI
Projection 4: Faults in domain KI
Projection 5: Dykes and veins in domain KI
Projection 6: F_3 fold axes and linear structures in domain KIII
Projection 7: F_3 fold axes in domain KIII
Projection 8: F_3 fold axes and linear structures in domain KV
Projection 9: F_3 fold axes in domain KV
Projection 10: F_3 axial planes in domain KV
Projection 11: Faults in domain GII
Projection 12: F_3 fold axes in domain GV
Projection 13: Synoptic plot of F_3 fold axes in domains KIII to KVII

Projection 14: Synoptic plot of faults, dykes and veins in domains GI and GVI
Projection 15: Structural elements in subdomains KIa and KIb
Projection 16: Structural elements in subdomain GIIIa
Projection 17: Structural elements in subdomains GVa, GVb and GVc

PLATES

Page

Plate 1: Variolitic basalt fragments ($1b_3$) in autobrecciated flow, southern Knee Lake. 7
Plate 2: Section through part of a pillow of variolitic basalt ($1b_3$) from southern Knee Lake. 8
Plate 3: "Clinopyroxene quench-texture" in andesite ($1b_1$) at Long Island. 9
Plate 4: Tectonically brecciated layer within strongly foliated, laminated amphibolite (1h) south of Seller Lake. 10
Plate 5: Fine grained feldspathic greywacke (1h) with F_3 fold from south of Seller Lake. 11
Plate 6: Porphyritic rhyolite ($2a_1$) at southern Knee Lake. 12
Plate 7: Chert fragment displaced from substrate during deposition of pyroclastic breccia (2b) — north shore of southern Knee Lake. 14
Plate 8: Magnetiferous iron formation (2c) of alternating chert and argillite laminae at Long Island, southern Knee Lake. 14
Plate 9: Tuffisite intrusion (3b) in magnetiferous iron formation at the east end of southern Knee Lake. 15
Plate 10: Feldspathic greywacke (3f), from southern Knee Lake. 16
Plate 11: Fine grained feldspathic greywacke (1h) from southern Magill Lake; F_3 phase of deformation. 17
Plate 12: Cataclasite (6d) at the north margin of the gneiss complex (6) at Magill Creek. 17
Plate 13: Pillow breccia ($1b_5$) within amygdaloidal pillowed basalt at northeastern Gods Lake. 18
Plate 14: Polygonal structures (cooling fractures?) in amygdaloidal pillowed basalt ($1b_4$) at Gods Lake. 19
Plate 15: Plagioclase phenocrysts in a basaltic matrix containing plagioclase microlites — from pillowed porphyritic basalt ($1c_2$) at Gods Lake. 19
Plate 16: Porphyroblastic plagioclase in basalt ($1b_2$), northeastern Gods Lake. 20
Plate 17: Megaphyric gabbro ($1e_2$) from northeastern Gods Lake. 21
Plate 18: Attenuated pillows in porphyritic basalt ($1c_2$), northeastern Gods Lake. 22
Plate 19: Finely laminated amphibolite (1h) with drag-folds, northern Gods Lake. 22
Plate 20: Ovoid structures of green hornblende in magnetiferous laminae of iron formation (2c), northeastern Gods Lake. 23
Plate 21: Primary folding and disruption of fine lamination in siltstone associated with iron formation (2c), northeastern Gods Lake. 23
Plate 22: Sedimentary microfaults in magnetiferous iron formation (2c) close to Elk Island, Gods Lake. 24
Plate 23: Interlayered feldspathic greywacke and siltstone (3e) near Elk Island, Gods Lake. 25
Plate 24: Channel deposit in medium- to coarse-grained feldspathic greywacke-siltstone sequence (3e), near Elk Island, Gods Lake. 26
Plate 25: Vitroclastic texture in a 30 cm thick felsic tuff layer (3e) within pillowed basalt near Elk Island, Gods Lake. 26
Plate 26: Crystal aggregate of plagioclase and hornblende in intermediate crystal tuff (3e) at Gods Lake. 27
Plate 27: Feldspathic greywacke (3f) with fragments in a biotite-bearing matrix — from Sturgeon Falls, Gods River. 27
Plate 28: Amphibolite xenoliths derived from basalt (1b) at northeastern Gods Lake, within tonalite (4b). 31
Plate 29: Intrusive breccia (4d) at northeastern Gods Lake containing clasts in a massive tonalite matrix. 32
Plate 30: Microcline megacrysts in granodiorite (7b) containing oriented inclusions; from Elk Island pluton, Gods Lake. 38
Plate 31: Oriented plagioclase inclusions (albite) in part of a microcline megacryst in granodiorite (7b); from Bayly Bay pluton, southern Knee Lake. 42
Plate 32: Flow lines in porphyritic andesite (8c). 43
Plate 33: Porphyritic andesite (8c) with hornblende pseudomorphs (after pyroxene) and corroded phenocrysts of plagioclase and quartz — from southern Knee Lake. 44
Plate 34: Tuff breccia (8e) with unsorted, angular clasts of volcanic and volcaniclastic rocks in a crystal-tuff matrix. 44
Plate 35: Interlayered tuff and pyroclastic breccia (8e) with moderately flattened clasts. 46
Plate 36: Matrix of pyroclastic breccia (8e); from southern Knee Lake. 47
Plate 37: Crystal tuff (8e), from southern Knee Lake. 47
Plate 38: Well layered, graded tuffs (8e). 48
Plate 39: Fine grained, graded sediments (8g) display flame structures, rip-ups, and parallel lamination. 48
Plate 40: Folded and disrupted layering in feldspathic greywacke-siltstone sequence (8g). 49
Plate 41: Folding, disruption, and reworking of fine grained sediments (8g) during deposition of relatively coarser grained, graded beds above. 49
Plate 42: Mafic tuff (8h) at southern Knee Lake. 50
Plate 43: Porphyritic diabase sill (8i) at southern Knee Lake. 50
Plate 44: Porphyritic basalt clast in pyroclastic breccia (8e) at southern Knee Lake. 51
Plate 45: Folded fragments in conglomerate (9b) at southern Magill Lake. 52
Plate 46: Conglomerate (9b) with well rounded cobbles and boulders, from Gods Lake. 56
Plate 47: Conglomerate (9b) with massive granitoid clasts and a well foliated, tabular mafic volcanic block — from Gods Lake. 56
Plate 48: Cross-bedded feldspathic greywacke (10a) at Trout Falls, Hayes River. 58
Plate 49: Well bedded, fine grained metasedimentary rocks (10f) at McLaughlin Lake. 58
Plate 50: Cordierite-biotite-muscovite schist (10f) from Magill Creek. 59

Plate 51: Amphibolite (10d) showing details of a folded garnetiferous layer, from Michikanes Lake. 60
Plate 52: Folded and disrupted pegmatite dykes (11b) close to the south margin of the Magill Lake pluton. 62
Plate 53: Porphyritic diabase dyke (12b) intrudes conglomerate (9b) in the area east of Magill Lake. 62
Plate 54: Kyanite relict within cordierite in intermediate volcanic fragmental rocks (2b) close to the south margin of the Elk Island pluton (7). 64
Plate 55: *En echelon* quartz veins filling fractures produced by late brittle deformation (D_5) in pyroclastic breccia (8e) at southern Knee Lake. 68

MAPS

Map GR83-1-1	Parker Lake	53M/2	in pocket
Map GR83-1-3	Semmens River	53N/4	in pocket
Map GR83-1-6	Oxford House	53L/14	in pocket
Map GR83-1-7	Knee Lake	53L/15	in pocket
Map GR83-1-8	McIvor Lake	53L/16	in pocket
Map GR83-1-9	Yellowback Island	53K/13	in pocket
Map GR83-1-11	Munro Lake	53L/11	in pocket
Map GR83-1-12	Vermilyea Lake	53L/10	in pocket
Map GR83-1-13	Gods Lake	53L/9	in pocket
Map GR83-1-14	Pesanapisko Lake	53K/12	in pocket

INTRODUCTION

Location and Access

The Knee Lake-Gods Lake area is located midway between Lake Winnipeg and the Hudson Bay lowlands in the northern part of the Precambrian Superior Province. Gods Lake Narrows (pop. = 1154) is the largest settlement in the area, occurring at the southeastern margin. The settlement, which is 550 km north-northeast of Winnipeg and 250 km southeast of Thompson, is connected by winter roads to Jenpeg on Cross Lake (230 km to the west) and Ilford on the CNR (182 km to the north-northwest). Airstrips are maintained at Gods Lake Narrows and at Elk Island (25 km to the east-northeast) and Gods River (41 km to the northeast). Scheduled air services operate from Winnipeg and Thompson to Gods Lake Narrows. Knee Lake is accessible by canoe from Norway House (approximately 5 days) via the Nelson, Echimamish and Hayes Rivers, along part of the historic route followed by the Selkirk settlers and early fur traders.

Physical Features and Drainage

Two major drainage systems cross the area — Hayes River flows northeast from Oxford Lake through Knee Lake to York Factory (on Hudson Bay); Gods Lake receives water from Beaver Hill Lake to the south and the flow continues north from Gods Lake via Gods River into Hayes River. Surficial deposits of sand, clay and boulder clay are extensive and several prominent eskers trend approximately north-south. Mapping of surficial deposits was undertaken by Barry during the geological survey of the Knee Lake area (Barry, 1959). Bedrock exposure is generally abundant at the shores of large lakes, but boulder-strewn shorelines devoid of outcrop are not uncommon, especially on relatively small lakes. Inland exposures of bedrock are generally sporadic owing to the extensive drift cover, but outcrop locally comprises up to 50 per cent of some inland areas. The relief is low, with localized ridges of outcrop and glacial deposits up to 25 m above the surrounding terrain. Prominent bedrock ridges rise 50 m above the water at Gods Lake Narrows.

Previous Work

The earliest references to the geology of the area are by John Richardson, who travelled with Franklin in the early nineteenth century, and by Robert Bell of the G.S.C. (1877 to 1879). Brock (1910) and McInnes (1913) also refer to the area in the G.S.C. publications. The first systematic mapping was undertaken by Bruce (1919) and Wright (1925, 1931 and 1932). The supracrustal rocks were recognized by Wright to consist of a lower mainly volcanic sequence (Hayes River Group) unconformably overlain by a sedimentary section (Oxford Group). This basic subdivision has been adopted in later work. Barry further divided the Hayes River Group into lower and upper units. More detailed mapping following Wright has been undertaken at Gods Lake (Dix, 1951; Barry, 1961), Knee Lake (Barry, 1959 and 1964) and Munro Lake (Barry, 1962). Further mapping has been undertaken in adjacent areas by Barry at Oxford Lake (1960), and Godard at Island Lake (1963). Reconnaissance maps covering parts of the area include those of Downie (1936), Springer (1947), Quinn (1960), Quinn and Currie (1961), Potter (1962) and Gross (1963).

Present Work

The Greenstone Project was initiated in 1970 to provide an improved geological data base in response to expanding base metal exploration. The project encompasses sixteen 30-minute NTS sheets, 3 half-sheets and 2 quarter-sheets, comprising an irregular area of approximately 16 200 km² bounded by longitude 93°30'W and 96°40'W and latitude 54°15'N and 55°15'N (Fig. 1). The central part of this area is the subject of this report; the geology of the remaining area is described by Hubregtse (1985), Elbers (in prep.) and Marten (in prep.).

The major part of the field work for this report was conducted in 1971 and 1972; minor investigations were conducted in 1973. Mapping in adjacent areas was continued by Marten (1973) and Hubregtse (1973-1974). Concurrent investigations of the geology, geophysics and geochronology of the greenstone project area were undertaken at the Mineral Resources Division and the University of Manitoba. Airborne geophysical surveys funded by the Federal and Provincial Governments have also been conducted (Gamma-ray Spectrometer survey in 1977, and electromagnetic-magnetic survey in 1977 and 1978). Preliminary reports and maps resulting from geological mapping have been published between 1971 and 1973; those currently available are listed in the Publications Catalogue of the Geological Services Branch. A review of the history of exploration of the area (up to 1960) is given by Barry (1961) and (up to 1977) by Southard (1977). A bibliography of the Greenstone Project is provided at the end of this report.

Mapping during the Greenstone Project was conducted at a scale of 2 inches = 1 mile and preliminary maps were published at that scale. The area mapped by the author amounts to approximately six 30-minute sheets (approximately 5400 km²). This report is accompanied by ten 30-minute NTS map sheets at a scale of 1:50 000, listed in Table 1.

This report describes, in turn, the four main groups of rocks in the Knee Lake-Gods Lake area, defined as the Hayes River Group, pre-Oxford Lake Group intrusives (Bayly Lake Complex), Oxford Lake Group, and post-Oxford Lake Group intrusives. The descriptions of each group are divided into geographic subareas, which can be identified from the topography shown in Figure 2. This is followed by descriptions of the metamorphic history and structural geology. The geochemistry of volcanic rocks at southern Knee Lake has been described by Barlow (1973), Green (1973, 1975) and Hubregtse (1976, 1978). The economic geology has been described by Southard (1977).

The terminology used in this report is that of primary rock types, although all rocks in the area (except for some dykes of unit 13) have been metamorphosed. The prefix "meta-" has not generally been employed in the interests of brevity. The classification of sedimentary lithologies is based on that of Pettijohn (1957). Pyroclastic rocks have been classified by fragment size after Fisher (1966). Plutonic rocks are classified by composition after Streckeisen (1967) and volcanic rocks after Middlemost (1973). Definition of clast size and grain size of volcanic and sedimentary rocks is according to the Wentworth scale. The grain size of plutonic rocks is defined in the following scale:

very coarse gained	= > 3 cm
coarse grained	= 0.5-3 cm
medium grained	= 1-5 mm
fine grained	= 0.3-1 mm
aphanitic	= < 0.3 mm

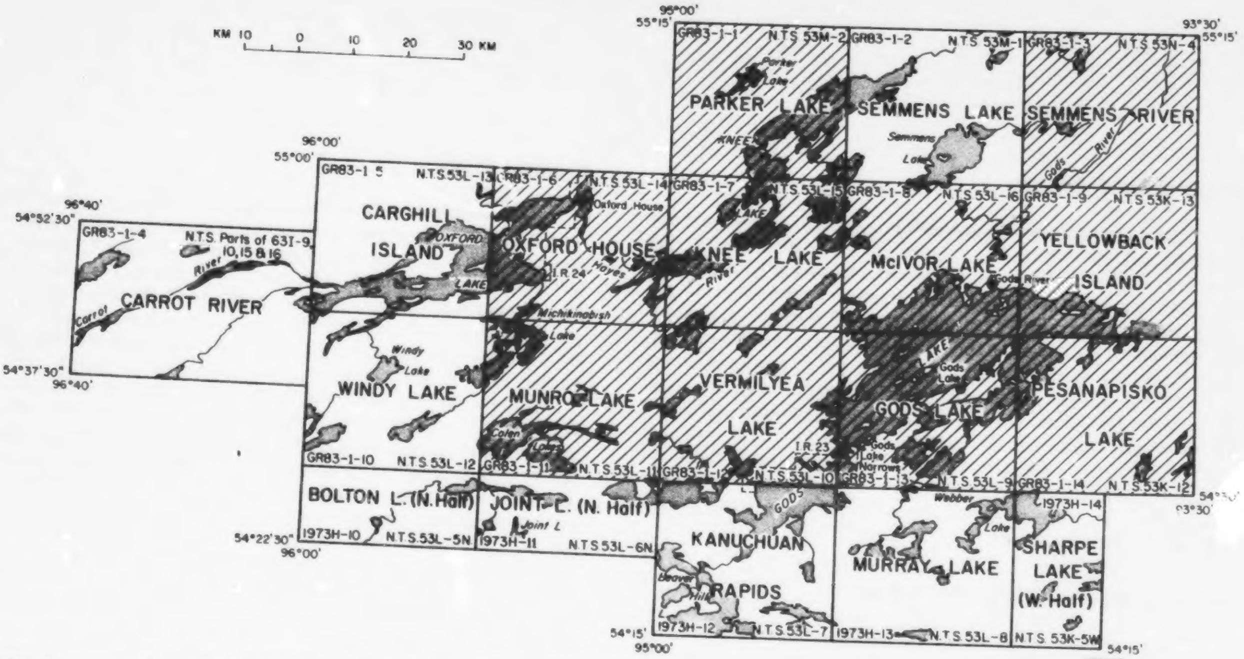

KM 10 0 10 20 30 KM
PARKER LAKE
SEMMENS LAKE
SEMMENS RIVER
CARGHILL ISLAND
OXFORD HOUSE
KNEE LAKE
McIVOR LAKE
YELLOWBACK ISLAND
CARROT RIVER
WINDY LAKE
MUNRO LAKE
VERMILYEA LAKE
GODS LAKE
PESANAPISKO LAKE
BOLTON L. (N. Half)
JOINT L. (N. Half)
KANUCHUAN RAPIDS
MURRAY LAKE
SHARPE LAKE (W. Half)
GR83-1-1 N.T.S 53M-2
GR83-1-2 N.T.S 53M-1
GR83-1-3 N.T.S 53N-4
GR83-1-4 N.T.S. Parts of 63I-9, 10,15 & 16
GR83-1-5 N.T.S 53L-13
GR83-1-6 N.T.S 53L-14
GR83-1-7 N.T.S 53L-15
GR83-1-8 N.T.S 53L-16
GR83-1-9 N.T.S 53K-13
GR83-1-10 N.T.S 53L-12
GR83-1-11 N.T.S 53L-11
GR83-1-12 N.T.S 53L-10
GR83-1-13 N.T.S 53L-9
GR83-1-14 N.T.S 53K-12
1973H-10 N.T.S 53L-5N
1973H-11 N.T.S 53L-6N
1973H-12 N.T.S 53L-7
1973H-13 N.T.S 53L-8
1973H-14 N.T.S 53K-5W
95°00' 55°15'
93°30' 55°15'
96°00' 55°00'
96°40' 54°52'30"
54°37'30" 96°40'
54°22'30" 96°00'
54°15' 95°00'
54°15' 93°45'
93°30'

Figure 1: *Greenstone Project area showing NTS map sheets; maps covering the Knee Lake-Gods Lake area are shaded.*

Table 1: Geological maps of the Knee Lake-Gods Lake area

Map	NTS area	Title	Author(s)
GR83-1-1	53M/2	Parker Lake	F.J. Elbers and H.P. Gilbert
GR83-1-3	53N/4	Semmens River	H.P. Gilbert and F.J. Elbers
GR83-1-6	53L/14	Oxford House	H.P. Gilbert, F.J. Elbers and J.J.M.W. Hubregtse
GR83-1-7	53L/15	Knee Lake	H.P. Gilbert and F.J. Elbers
GR83-1-8	53L/16	McIvor Lake	H.P. Gilbert
GR83-1-9	53K/13	Yellowback Island	H.P. Gilbert
GR83-1-11	53L/11	Munro Lake	F.J. Elbers and H.P. Gilbert
GR83-1-12	53L/10	Vermilyea Lake	H.P. Gilbert, B. Marten and F.J. Elbers
GR83-1-13	53L/9	Gods Lake	H.P. Gilbert and B. Marten
GR83-1-14	53K/12	Posanapisko Lake	H.P. Gilbert

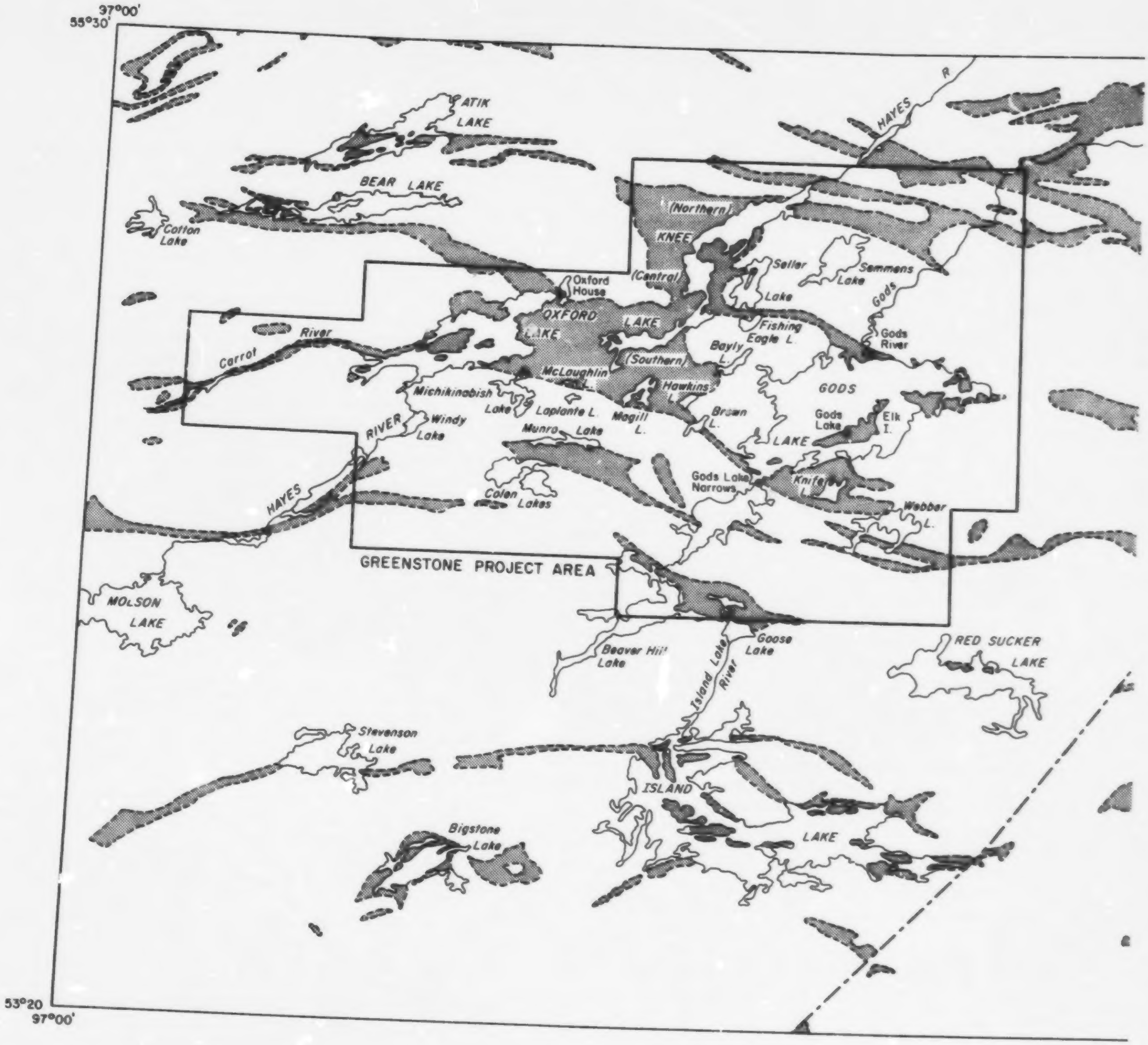
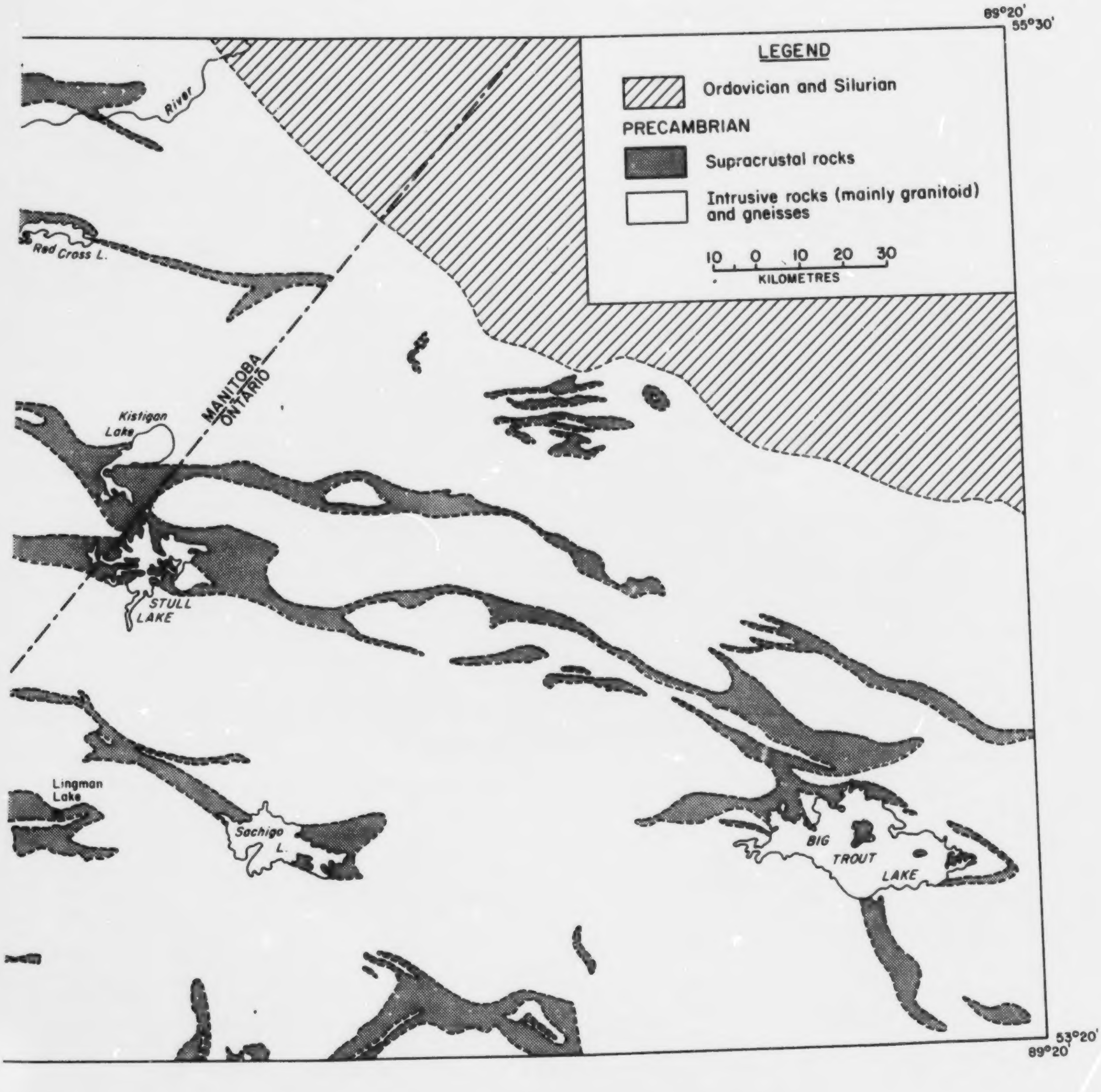

97°00'
55°30'
ATIK
LAKE
BEAR LAKE
Cotton
Lake
HAYES
R
(Northern)
KNEE
(Central)
Oxford
House
OXFORD
LAKE
LAKE
Seller
Lake
Semmens
Lake
Gods
Gods
River
Fishing
Eagle L.
Bayly
L.
Carrot
River
(Southern)
McLaughlin
Hawkins
L.
GODS
Michikinabish
Lake
Windy
Lake
Laplante L.
Magill
L.
Brown
L.
Gods
Lake
Elk
I.
RIVER
Munro
Lake
LAKE
Gods Lake
Narrows
Knife
L.
HAYES
Colen
Lakes
Webber
L.
GREENSTONE PROJECT AREA
MOLSON
LAKE
Beaver Hill
Lake
Goose
Lake
Island Lake
River
RED SUCKER
LAKE
Stevenson
Lake
ISLAND
LAKE
Bigstone
Lake
53°20
97°00'

Figure 2: Distribution of supracrustal rocks in the northern Superior Province and location of the Greenstone Project area.

Acknowledgements

The following provided competent and cheerful assistance during the field work: N.L. Green, L. Solkoski, D. Smart, M. Williams. C. Boreski, B. McKenzie, B. Dolan, R. Whitworth and G. Kosack. Maps and figures in this report have been prepared by the Draughting Section of the Mineral Resources Division; final maps were drafted by T. Franceschet, D. Bagwell and M. Timcoe. Laboratory work, including preparation of thin sections, stained slabs, and geochemical analyses and assays, was undertaken by the laboratory of the Mineral Resources Division under the direction of A. Asham, D. Berk and A.M. MacKay. Thanks are extended to all the above and in particular to the other geologists in the project — F.H.A. Campbell, F.J. Elbers, S.C. Elphick, J.J. Hubregtse and B. Marten. Thanks are also due to B. Thakrar and L. Chudy who typed the manuscript.


89°20'
55°30'
LEGEND
Ordovician and Silurian
PRECAMBRIAN
Supracrustal rocks
Intrusive rocks (mainly granitoid) and gneisses
10 0 10 20 30
KILOMETRES
River
Red Cross L.
MANITOBA
ONTARIO
Kistigan Lake
STULL LAKE
Lingman Lake
Sachigo L.
BIG TROUT LAKE
53°20'
89°20'

GENERAL GEOLOGY

Regional Setting

The Knee Lake-Gods Lake greenstone belt is part of a system of linear, branching belts of supracrustal rocks in the northern part of the Superior Province, extending for approximately 500 km from Cotton Lake (Manitoba) in the west (long. 96°50') to Big Trout Lake (Ontario) in the east (long. 89°30') (Fig. 2). The northern limit of the system (extrapolated by aeromagnetic data) is at approximately lat. 55°25' north and the southern margin (in Ontario) extends to lat. 53°22'. The supracrustal belts are separated by extensive granitoid terranes comprising many intrusive phases of massive to gneissoid rocks and containing sporadic remnants of supracrustal rocks. The stratigraphies of the supracrustal belts are similar comprising a lower largely volcanic section, in which cycles of volcanism can locally be recognised (Hubregtse, 1976), overlain by a predominantly sedimentary succession. These rocks are intruded by diapiric granites of at least two ages (pre- and post- the upper sedimentary succession). The margins of the supracrustal belts are intruded by the surrounding granitoid rocks. Some contacts are strongly sheared with localized mylonite units, possibly representing major faults; the southern margin of the Oxford Lake-Knee Lake greenstone belt corresponds to a major topographic lineament and mylonite occurs at the contact near Magill Lake and at Gods Narrows.

Radiometric ages obtained in the Greenstone Project area are shown in Table 2. The Rb/Sr data and single U/Pb age range from 2.42-2.7 Ma. K/Ar data include Kenoran ages and some younger dates which probably reflect resetting of original Kenoran ages by later thermal events, except for the late gabbro at Gods Lake (1105 ± 140 Ma). The age of the oldest granitoid rocks approximates the ages obtained for the Hayes River Group volcanic rocks. Pre-Hayes River Group granitoid rocks have not been recognized in the field, but the possible occurrence of such older rocks within the granitoid terranes flanking the greenstone belts has been discussed since mapping began in the area; the nature of the surface on which the Hayes River Group was deposited is still not known. Pre-Kenoran ages (2.9 and 3.0 Ma) have been recorded for gneiss and quartz diorite within the granitoid terrane 350 km south of the Greenstone Project area (Krogh et al., 1974).

The relative ages of supracrustal rocks in different greenstone belts in the northern part of the Superior Province is not known. The stratigraphic subdivision (Hayes River Group, Oxford Lake Group) has been applied throughout the area of the Greenstone Project, but the stratigraphy of the Munro Lake greenstone belt cannot be directly correlated with that of the Oxford Lake-Knee Lake-Gods Lake belts (Fig. 2). The term Hayes River Group has also been applied to the lower parts of the section at Island Lake (Godard, 1963) and Cross Lake (Rousell, 1965), but these areas are separated from the Greenstone Project area by extensive granitoid terranes.

Summary of Geology and Geological History

The Hayes River Group consists predominantly of mafic volcanic flows, with subordinate felsic and intermediate extrusive and volcanic fragmental rocks and minor fine grained sedimentary rocks (Table 3). Mafic volcanics are especially abundant in the lower part of the Hayes River Group in the area north of southern Knee Lake* and at Elk Island, Gods Lake. The flows are interlayered with related gabbro sills and rare, thin (1-5 m) sedimentary units including iron formation, chert, greywacke, and tuffaceous lithologies. Felsic volcanic rocks are best developed in the upper part of the Hayes River Group at the north shore of southern Knee Lake, where the Hayes River Group consists of five volcanic cycles (Hubregtse, 1976). Each cycle consists of a mafic base and relatively thin intermediate to felsic volcanic upper section, locally containing minor sedimentary rocks including iron formation. The maximum thickness of this volcanic section is 9.65 km. The base of the section is intruded by a granodiorite pluton to the north and thus the original extent of the lower Hayes River Group is unknown. The section extends laterally northeast and then north into the central and northern parts of Knee Lake (Elbers, in prep.); the westward extension through Oxford Lake has been mapped by Hubregtse (1985). A subsidiary branch of the section extends between Seller and Fishing Eagle Lakes to the northern part of Gods Lake where the Hayes River Group consists very largely of pillowed basalt and derived mafic gneiss and schist. The maximum thickness of the Hayes River Group at Gods Lake, which occurs at Elk Island, is 10.45 km. The base of the section south of Elk Island is in contact with a younger granitoid pluton and the original thickness is unknown.

The greenstone belt at Gods Lake consists of three converging branches which meet in the vicinity of northern Elk Island; the regional distribution of these rocks is probably largely governed by the emplacement of younger granitoid diapirs of the Bayly Lake Complex (Table 3). The relatively thin parts of these belts are more altered and attenuated than more thickly developed sections. The Hayes River Group at Gods Lake is apparently not cyclic, and has been deformed in several major folds, in contrast to the monoclinal, cyclic section at southern Knee Lake. The early folds probably predate the emplacement of granitoid plutons of the Bayly Lake Complex since the latter locally truncate and deform these structures (e.g., at northern Elk Island). Furthermore, the plutons contain xenoliths of Hayes River Group basalt which were foliated prior to incorporation, indicating a phase of deformation predating the plutonism. However, the early folds were probably accentuated during emplacement of the granitoid rocks.

The Hayes River Group at Gods Lake is unconformably overlain by basal boulder-conglomerate of the Oxford Lake Group (unit 9) in the core of the syncline north of Elk Island. The conglomerate contains fragments of volcanic and sedimentary rocks derived from the Hayes River Group and granitoid clasts attributed to the Bayly Lake Complex. Some mafic clasts display pre-depositional foliations. The Hayes River Group at southern Knee Lake is overlain by predominantly volcanic fragmental rocks of the lower Oxford Lake Group (unit 8). The only exposed contact between the two groups at southern Knee Lake is very strongly sheared. The structural trends of the two groups are slightly discordant in that area, consistent with the inferred unconformable relationship between these groups. An unconformity is also indicated by the occurrence of a body of basal Oxford Lake Group conglomerate east of Magill Lake which truncates the west- to northwest-trending Hayes River Group mafic flows in that area.

The extent of pre-Oxford Lake Group erosion of the upper Hayes River Group strata is not known but was probably at least 1 km, in order to expose the plutonic rocks of the Bayly Lake Complex which occur as fragments in the basal conglomerate. In the Oxford Lake area, the common occurrence of greywacke fragments of inferred Hayes River Group origin in the basal conglomerate suggests a formerly more extensive development of sediments in the upper Hayes River Group because metasedimentary rocks are only a very minor component of the existing Hayes River Group section in that area (Hubregtse, 1985). The duration represented by the unconformity is also unknown; the ages

---

*Southern Knee Lake refers to that part of Knee Lake south of Opischikona Narrows at lat. 54°58'N.

Table 2: Isotopic ages from the Greenstone Project area

Method	Sample Locality	Date (Ma)	Greenstone Project Map-unit Number	Lithology	Reference
K/Ar	Oxford Lake Lat. 54°48'N Long. 95°35'W	2200	7b	Granite	Moore, J.M. et al., 1960
K/Ar	Magill Lake Lat. 54°45'N Long. 94°55'W (Magill Lake pluton)	1640	11a	Granite	
K/Ar	Gods Lake Lat. 54°32'N Long. 94°30'W	2380	6	Granodiorite	Burwash, R.A. et al., 1962
K/Ar	Gods Lake Lat. 54°38'N Long. 94°16'W (Elk Island pluton)	2620	7	Granodiorite	
K/Ar	Seller Lake Lat. 55°02'N Long. 94°27'40''W (Seller Lake pluton)	2005	7	Granite	Leech, G.B. et al., 1963
K/Ar	Gods Lake Lat. 54°47'N Long. 94°16'W	1105 ± 140	13	Gabbro	Wanless, R.K. et al., 1966
Rb/Sr	Magill Lake pluton	2455 ± 35	11a	Granite	Clark, G.S. and Cheung, S.P., 1977
Rb/Sr	Bayly Bay pluton	2424 ± 74	7b	Granodiorite	
Rb/Sr	Goose Lake	2680 ± 125	Uncertain-either Hayes River or Oxford Lake Group	Rhyolite tuff	
U/Pb	Southern Knee Lake	c.2700	2a,	Rhyolite	G. Hansen in Clark, G.S. and Cheung, S.P., 1977
Rb/Sr	Oxford Lake	2650 ± 80	8	Andesite-dacite	Brooks, C. et al., 1982

of the Hayes River Group and Oxford Lake Group are not distinguishable by available dates which indicate an approximate age limit of 2.7 Ma for both groups (Table 2). The radiometric age of the (pre-Oxford Lake Group) Bayly Bay pluton (2424 ± 74 Ma) is not consistent with that of the Oxford Lake Group (2650 ± 80 Ma) nor the (post-Oxford Lake Group) Magill Lake pluton (2455 ± 35 Ma); this may result from thermal effects post-dating the Bayly Bay pluton (G. Clark, pers. comm.).

The volcanic part of the Oxford Lake Group is well developed at both Oxford Lake (Hubregtse, 1985) and southern Knee Lake, where this section (up to 790 m thick) consists largely of intermediate volcanic fragmental deposits with subordinate flows and related sedimentary rocks. This section is conformably overlain by volcanogenic greywacke and conglomerate (upper Oxford Lake Group) which underlie a major terrane up to 13.5 km wide which extends for approximately 60 km from Oxford Lake (in the west) to Hawkins Lake (in the east). A thin (1 m) iron formation locally occurs close to the base of the upper Oxford Lake Group section at southern Knee Lake. A unit of massive and pillowed basalt within the Oxford Lake Group sedimentary basin has been interpreted as a structural inlier of the Hayes River Group. The Oxford Lake Group rocks have been deformed in several major folds and have undergone amphibolite facies metamorphism and intrusion of granodiorite plutons and minor pegmatite bodies. Mafic volcanogenic

Table 3: Table of Formations, Greenstone Project area

		PLEISTOCENE DEPOSITS
		unconformity
INTRUSIVE	13	diabase, gabbro, olivine norite
	12	diabase, gabbro
ROCKS	11	granodiorite, granite
		intrusive contact
OXFORD	10	greywacke, arkosic wacke, argillite, minor iron formation and amphibolite
LAKE	9	conglomerate, minor greywacke
GROUP	8	porphyritic volcanic flows and pyroclastic rocks (absarokite, shoshonite, andesite, dacite and rhyolite); related sedimentary rocks
		unconformity
BAYLY	7	tonalite, granodiorite, granite; minor syenite
	6	gneissoid tonalite; minor gabbro, hornblendite, clinopyroxenite and amphibolite
LAKE	5*	andesitic volcanic fragmental rocks and related sedimentary rocks (Lynx Bay assemblage)
COMPLEX	4	gneissoid tonalite, granodiorite and minor granite; minor mafic intrusive rocks and intrusive breccia
		intrusive contact
HAYES	3	volcanogenic greywacke and minor conglomerate; minor volcanic rocks
RIVER	2	rhyolite and dacite flows and volcanic fragmental rocks; minor related sedimentary rocks and iron formation
GROUP	1	basalt and andesite, mainly pillowed flows; related gabbro and minor ultramafic rocks; minor volcanic fragmental and sedimentary rocks

*Oxford Lake-Carrot River Area only (Hubregtse, 1985)

gneiss and amphibolite of the Hayes River Group (up to 850 m thick) extend along the southern margin of the Oxford Lake Group sedimentary basin. The southern margin of this unit is intruded by granitoid rocks of the Bayly Lake Complex which extend south to the Munro Lake greenstone belt (Munro Lake area, NTS 53L-11). The contact between the Hayes River Group rocks and the granitoid terrane to the south, which is marked by a prominent topographic lineament, is highly sheared and mylonitized and probably corresponds to a major fault.

Fine grained metasediments of uncertain age outcrop on Gods River in the northern part of the Semmens River area (NTS area 53N-4). These rocks apparently comprise the southern limb of a syncline. Extreme aeromagnetic anomalies indicate the presence of iron formation within this section. Lithologic associations and regional stratigraphic relationships indicate a Hayes River Group age for these rocks, which are separated from the Knee Lake-Gods Lake greenstone belt by an extensive granitoid terrane.

The youngest igneous rocks are post-tectonic mafic dykes (unit 13, Table 3), which are probably of Aphebian age (Hubregtse, 1978) or younger; one northwest-trending dyke at Gods Lake has been dated (K-Ar) at 1105 ± 140 Ma (Wanless et al., 1966).

HAYES RIVER GROUP

Southern Knee Lake Area

METAMORPHOSED MAFIC VOLCANIC AND RELATED SUBVOLCANIC ROCKS; MINOR ULTRAMAFIC ROCKS, MINOR SEDIMENTARY ROCKS (1)

Serpentinized peridotite ($1a_2$)

Serpentinized peridotite outcrops at three locations along the north shore of southern Knee Lake. The ultramafic rocks occur as stratiform lenses and are associated with moderate positive aeromagnetic anomalies. North-trending, talcose ultramafic dykes in porphyritic rhyolite at the northwest extremity of southern Knee Lake are probably related to the adjacent sill (Knee Lake area, NTS 53L/15).

The massive ultramafic rocks weather pale grey-green or beige and are locally veined by picrolite, asbestos, or carbonate. Traces of igneous layering occur in the body at Pain Killer Bay. The ultramafic lenses are associated with gabbro sills at their southern flanks. The westernmost ultramafic body is intruded by the adjacent gabbro; the contact between this ultramafic and felsic volcanic rocks (2a) to the north is strongly sheared. The margins of the other ultramafic sills are not exposed.

Serpentine constitutes up to 70 per cent of the ultramafic rocks; clinopyroxene, biotite and magnetite are the only primary minerals preserved. Olivine is completely altered to serpentine and secondary opaque minerals; anhedral red-brown biotite locally contains altered olivine grains. Colourless clinopyroxene is partly altered to tremolite ± epidote ± carbonate. Chlorite is widespread, as interstitial fine grained aggregates (± serpentine) or as an alteration of biotite or tremolite; sphene and tourmaline are minor accessories.

Basalt, minor andesite, related sills, minor basic tuff (1b)
Porphyritic andesite and basalt, minor dacite and related sills (1c)
Megaphyric andesite, basalt and related minor intrusions (1d)

Mafic volcanic flows and related gabbro extend from the area north of northeastern Oxford Lake eastwards to southern Knee Lake and from there northwards to central Knee Lake (Oxford House and Knee Lake areas, NTS 53L/14 and 15). The mafic volcanic rocks alternate with intermediate to felsic volcanic units forming five volcanic cycles (Hubregtse, 1976). The mafic sections of a single volcanic cycle may be subdivided on the presence or absence of plagioclase phenocrysts or megaphenocrysts (defined as <1 cm and >1 cm long, respectively). The flows are generally pillowed; very minor fragmental rocks are intercalated with the flows. Small gabbro sills are common within the mafic flows, but only the larger bodies ($>$ 10 m wide) have been identified on the maps. A unit of variolitic pillowed basalt ($1b_3$) up to 350 m thick extends for at least 22 km through southern Knee Lake. A unit of pillowed basalt within feldspathic greywacke (10a) south of southern Knee Lake is interpreted as a structural inlier of the Hayes River Group.

Mafic flows at southern Knee Lake are massive to well foliated, and weather grey-green to dark green, locally cream or pale grey; fresh surfaces are medium to dark grey. Pillows are moderately flattened parallel to the regional foliation, but still provide reliable indications of top direction. The ovoid pillows (0.3-1.5 m long) are rimmed by dark selvages of hornblende (± epidote). Rare zones of flow breccia occur within the mafic flows; hyaloclastic structure occurs within variolitic basalt at the north shore of Long Island and at the south shore of the island south of Oskatakak Narrows (Plate 1).

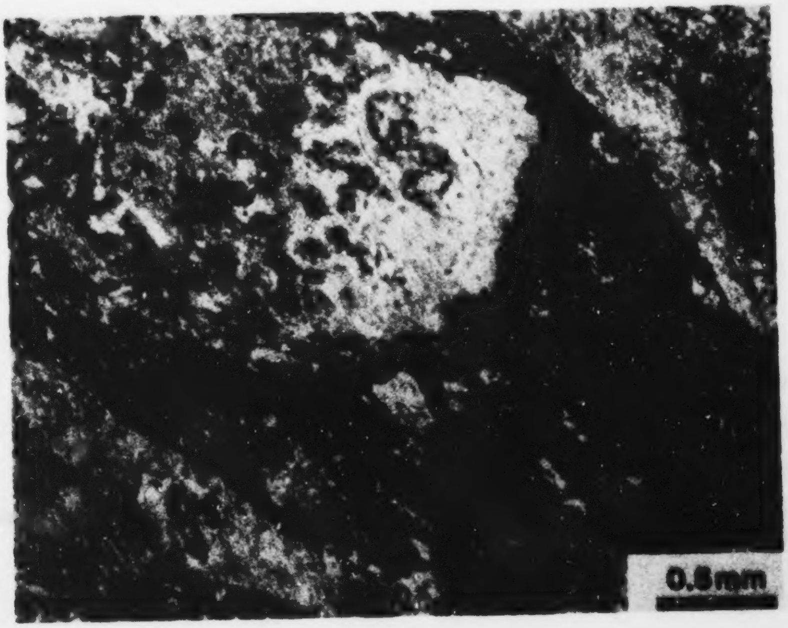


Plate 1: *Variolitic basalt fragments ($1b_3$) in autobrecciated flow, southern Knee Lake. (Plain light).*

Porphyritic mafic volcanic rocks are similar to their aphyric equivalents. Plagioclase phenocrysts (up to 5 mm long) constitute 10-35 per cent of porphyritic basalt (1c). Megaphyric rocks are characterized by glomeroporphyritic texture, with plagioclase phenocrysts and pseudohexagonal aggregates which are 1-5 cm in diameter (average), up to 7 x 12 cm. The phenocrysts generally constitute 10-50 per cent (up to 80 per cent) of the megaphyric rocks (1d).

Pale green variolites in pillowed basalt ($1b_3$) are 2-3 mm (up to 1 cm) in diameter and decrease in size and abundance towards pillow margins; the variolites commonly coalesce towards pillow cores (Plate 2). One andesite flow at the south shore of Long Island displays aggregates of subparallel to radiating tremolite blades in a chloritic matrix (Plate 3) interpreted as an altered "clinopyroxene quench-texture" (R.F.J. Scoates, pers. comm.). Non-pillowed basalt adjacent to variolitic basalt at southeastern Long Island locally contains radiating plagioclase aggregates also interpreted as a quench texture.

The mafic volcanic flows are gradational with epidote amphibolite (1g) which is the result of alteration and extreme attenuation in which pillow selvages are disrupted to irregular lenses and stringers of epidote. Such deformation is characteristic of some flows close to the margins of granitoid plutons. Extensive carbonatization, or alteration of basalt to epidote in irregular masses and lenses occurs locally. Sheared zones occur within the mafic volcanic units and at their margins. The zones are typically 1 cm-1 m wide (locally up to 5 m). Concordant veinlets and stringers of quartz and feldspar, carbonate, chlorite, or epidote are common. Rare discontinuous trails of magnetite, epidote or chlorite normal to the foliation may represent fillings of early fractures.

The contact between the Hayes River Group and the Oxford Lake Group at the west and south shores of southern Knee Lake is strongly sheared over a width of up to 25 m. A 30 m wide shear zone between pillowed basalt ($1b_2$) and feldspathic greywacke (3f) is interpreted to extend for at least 18 km through southern Knee Lake; the shear coincides with iron formation (2c) at the island south of Oskatakak Narrows. Rare mafic tuff and siliceous feldspathic greywacke interlayers (0.5-2 m thick) occur within basalt in the area between southern Knee Lake and Seller Lake.

Microscopic examination shows that basalt and andesite consist essentially of amphibole (tremolite-actinolite or hornblende) and plagioclase; accessories include calc-silicates, carbonate, micas, quartz, apatite, opaque minerals and rare garnet and tourmaline. The various weathering colours of mafic volcanics are controlled largely by the type of amphibole (tremolite-bearing rocks are lighter than those containing hornblende); dark tones in some tremolitic rocks are due to chlorite; carbonate results in pale weathering colours.

Tremolite-actinolite is the most common amphibole, forming approximately 50 per cent of the rocks; green hornblende occurs at Seller Lake and sporadically in the area north of Hawkins Lake. Plagioclase phenocrysts (An_{48}-An_{84}) are subhedral and commonly normally zoned. Elongate plagioclase laths in the matrix are generally albite or oligoclase (rarely more calcic, up to An_{60}) and locally contain central trails of fine grained amphibole. Sericitization and saussuritization of plagioclase is widespread; carbonate locally replaces plagioclase, and is commonly abundant in shear zones. Amphibole is locally altered to chloritic pseudomorphs. Accessory sphene is ubiquitous; green-brown biotite is rare. The flows north of Hawkins Lake contain up to 10 per cent plagioclase phenocrysts and locally contain up to 10 per cent disseminated magnetite; clinopyroxene is a rare accessory. Several of these rocks contain aggregates of pyrite with concentric rims of epidote (inner), hematite, and magnetite (outer).

The mafic flows at southern Knee Lake locally contain immiscible segregations consisting of ovoid aggregates of clinozoisite, sphene, chlorite and plagioclase. Plagioclase phenocrysts occur within the aggregates or close to their margins in the tremolite-chlorite matrix. Amoeboid bodies of tremolite and sphene occur in the same rocks. Sporadic occurrences of "plagioclase quench-texture" consist of radiating plagioclase aggregates forming variolitic structures up to 1 cm across with carbonate-rich cores. Altered "clinopyroxene quench-texture" consists of elongate tremolite blades (up to 1 cm long) with fine trails of sphene inclusions in subparallel to radiating aggregates in a fine grained chloritic matrix with minor tremolite, sphene, and clinozoisite.

Variolites consist of roughly spherical structures containing actinolite, epidote and clinozoisite; concentric zoning is common, with epidote or chloritic cores and actinolite rims. The original minerals are

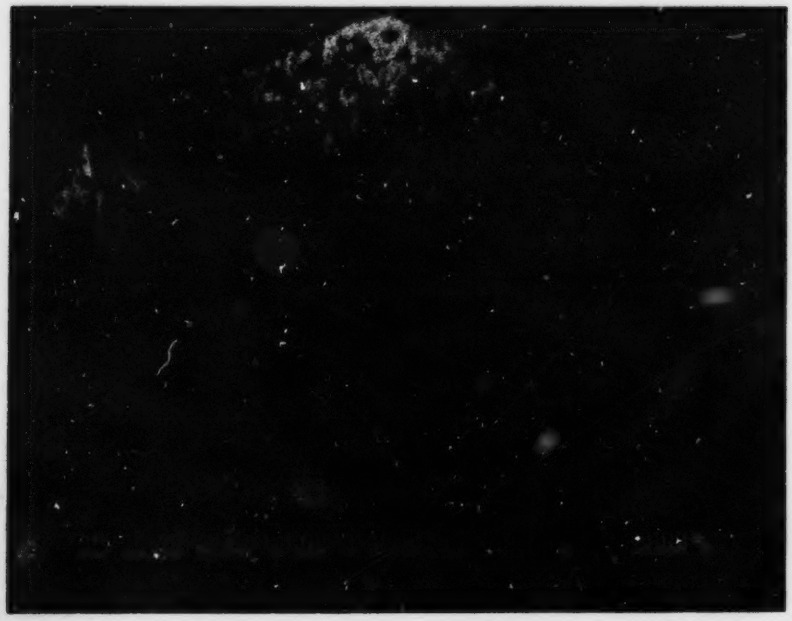
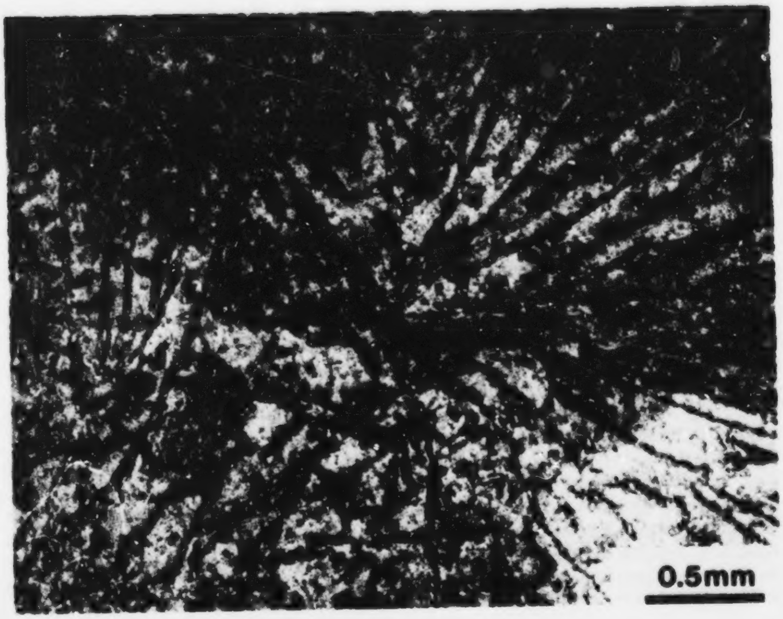


Plate 2: *Section through part of a pillow of variolitic basalt ($1b_3$) from southern Knee Lake; epidotic variolites decrease in size and abundance towards the margin of the pillow (central part of photograph).*

Plate 3. *"Clinopyroxene quench-texture" in andesite ($1b_1$) at Long Island, southern Knee Lake, consisting of radiating blades of tremolite (± sphene) in a chloritic matrix. (Plain light).*



interpreted as plagioclase and clinopyroxene. The variolites partly enclose plagioclase laths and subhedral pseudomorphic aggregates of quartz and chlorite. Pumpellyite occurs rarely in the variolites. The matrix of variolitic rocks consists of pale green amphibole and chlorite (± clinozoisite), with minor sphene and epidote (± quartz). Felsic lenses (up to 8 x 2 cm) occur locally in pillowed porphyritic basalt ($1c_2$) close to the south shore of Seller Lake. The lenses comprise very fine grained aggregates of quartz and (probable) albite with rims of clinozoisite; similar structures have been interpreted as variolites by Gélinas et al. (1976). The sequence of crystallization for variolitic basalt is as follows:

1. Plagioclase (fine grained laths overprinted by variolites) and mafic phenocrysts (now quartz-chlorite pseudomorphs).
2. Plagioclase and clinopyroxene (variolites).
3. Devitrification of the matrix and alteration of plagioclase-clinopyroxene variolites.

Variolites are commonly considered to be the result of rapid cooling of mafic volcanic flows (Gélinas et al., op. cit.; Seguin and Laurent, 1975). This interpretation is supported by the occurrence of "quench textures" in or close to the variolitic flows at southern Knee Lake. The variolites resemble "globulites" described by Seguin and Laurent (op. cit.) and interpreted as immiscible segregations in a glassy matrix which decreases towards the pillow cores.

Equigranular gabbro ($1e_1$)
Porphyritic gabbro ($1e_2$)
Mesocratic porphyry, quartz gabbro, granophyre ($1e_4$)

Gabbro is a generally massive, green weathering rock, commonly with speckled appearance due to randomly oriented hornblende and plagioclase. Megaphyric and glomeroporphyritic gabbros occur locally in association with megaphyric flows (1d). The gabbros are generally homogeneous, but diffuse feldspathic or hornblendic zones occur locally; grain size is medium to coarse, locally very coarse with hornblende crystals up to 6 cm long in rare pegmatitic zones. Basaltic xenoliths occur sporadically. Chilled margins are locally preserved, but the margins are commonly well foliated and primary features destroyed.

Gabbro consists mainly of amphibole and plagioclase; accessory sphene and quartz constitute 5-10 per cent of the rock. Minor accessories include biotite, magnetite, pyrite, apatite and secondary epidote, carbonate, chlorite and sericite. Amphibole (actinolite or green to blue-green hornblende) is commonly twinned and poikiloblastic; sporadic relicts of clinopyroxene and/or brown biotite occur within amphibole in the relatively large gabbro body immediately west of Opischikona Narrows. Rare brown patches within green hornblende may represent relicts of a primary amphibole but generally green hornblende is interpreted as a replacement of original pyroxene. The subhedral amphibole poikiloblasts are locally strained, dislocated, and partly recrystallized to finer grained green hornblende or altered to tremolite, chlorite, epidote, carbonate and rare biotite. Plagioclase (generally andesine, ranging from albite to labradorite) is anhedral to subhedral and normally zoned. Altered ophitic texture in some large gabbro sills consists of inclusions of plagioclase within hornblende pseudomorphs after pyroxene. Minor fine grained sphene is commonly associated with ilmenite and leucoxene; locally sphene occurs intersertally or as prominent subhedral grains. Some sphene contains corroded inclusions of plagioclase, quartz or granophyric intergrowths. Quartz is locally intersertal, commonly in granophyric intergrowths with plagioclase or, more rarely, microcline. Secondary epidote, chlorite, sericite, biotite and carbonate are generally minor, except in well foliated or sheared zones.

Mafic to intermediate pyroclastic rocks, minor greywacke, argillite and basalt (1f)

Crystal- and lapilli-tuffs comprise units up to 15 m thick within the mafic volcanic section in the northeast part of southern Knee Lake and in the area south of Seller Lake (Knee Lake area, NTS 53L/15). The tuffs are locally associated with pyroclastic breccia and fine grained sedimentary rocks. South of Seller Lake, the tuffs are generally mafic and hornblendic (locally intermediate and micaceous) and contain mixed assemblages of felsic to mafic porphyritic clasts. The pyroclastic rocks (1f) east of Kakinok Island (at the northeast part of southern Knee Lake) are strongly foliated and their fragmental character is largely obliterated.

Epidotized basalt, epidote amphibolite (1g)
Amphibolite, amphibolitic schist, minor feldspathic greywacke (1h)

Interlayered amphibolite and feldspathic greywacke comprise the major part of the supracrustal section (approximately 1 km wide) between Seller and Fishing Eagle Lakes. This section extends west and northwest to Opischikona Narrows where greywacke and argillite (3b) overlie basalt (1b, 1c) in a synclinorial structure (Knee Lake area, NTS 53L/15). Minor gabbro ($1e_1$) and pyroclastic lenses (1f) occur in this zone south of Seller Lake and in the area to the west. Southeast of Seller Lake, the supracrustal rocks extend to the northwest part of Gods Lake, where the section consists largely of basalt and related amphibolite (1b, 1c, 1g, 1h); continuity of the supracrustal rocks between Seller Lake and Gods Lake is inferred from aeromagnetic trends (Map 4027G, McIvor Lake, Federal-Provincial Aeromagnetic Series).

AMPHIBOLITE

The amphibolite generally displays lamination (at a scale of 1-10 cm) defined by variable hornblende, quartz, plagioclase and/or epidote contents, and grain size variation. Plagioclase-phyric amphibolite and medium grained amphibolite interlayers with subhedral hornblende pseudomorphs and aggregates (up to 1 cm) constitute 5-10 per cent of the sequence. These interlayers (0.1-2 m thick, locally up to 60 m) are not laminated and are interpreted as flows and/or sills. Pillowed porphyritic basalt ($1c_2$) occurs within finely laminated amphibolite (1h) close to the south shore of Seller Lake.

Rare, thin (5 cm) interlayers of tectonic breccia within laminated amphibolite contain angular fragments of well foliated amphibolite in a very fine grained epidotic matrix (Plate 4). Felsic stringers, epidotic laminae and minor folding (with associated strain-slip cleavage) are characteristic of the laminated amphibolite south of Seller Lake. Some epidotic bodies have Y-shaped forms interpreted as relicts of disrupted pillow selvages.

Andesine and green hornblende are the essential minerals; the latter occurs as subparallel pseudomorphs or aggregates with inclusions of quartz, plagioclase, and rare biotite.

Biotite constitutes 1-2 per cent of the rock and is locally concentrated in thin limonitic laminae which are microcrenulated. Epidote and clinozoisite are common accessories, and are locally abundant (up to 50 per cent of the rock). Minor accessories include quartz, sphene, ilmenite, apatite, magnetite, and pyrite. Rare accessories include clinopyroxene and secondary stilpnomelane and muscovite. Sericitization of plagioclase is widespread.

FELDSPATHIC GREYWACKE

Feldspathic greywacke beds (0.6-3 m) constitute approximately 5 per cent of the section south of Seller Lake, and are interlayered with amphibolite. The greywacke is pale grey to beige, massive to laminated (at 0.5-5 cm) and locally displays very fine micaceous laminae (Plate 5). Medium grained detrital quartz and feldspar (up to 30 per cent of the rock) occur in a fine grained, intermediate to siliceous matrix. Quartzofeldspathic and rare carbonate veins and stringers are parallel or subparallel to the layering. Feldspathic greywacke is generally intermediate (10-20 per cent hornblende and/or biotite) but is locally more siliceous or more micaceous.

Greywacke contains detrital andesine which is locally antiperthitic, and is commonly crowded with very fine, ovoid quartz inclusions. One granodiorite granule with myrmekitic plagioclase was observed. Accessory minerals include epidote, sphene, apatite, magnetite, pyrite and sericite. Carbonate and chlorite are generally minor constituents but constitute up to 20 per cent of some greywacke.

METAMORPHOSED FELSIC VOLCANIC, SUBVOLCANIC, AND RELATED SEDIMENTARY ROCKS (2)

Porphyritic felsic volcanic flows ($2a_1$) occur in a lensoid body approximately 18 km long which is 1.7 km thick (maximum) at Pain Killer

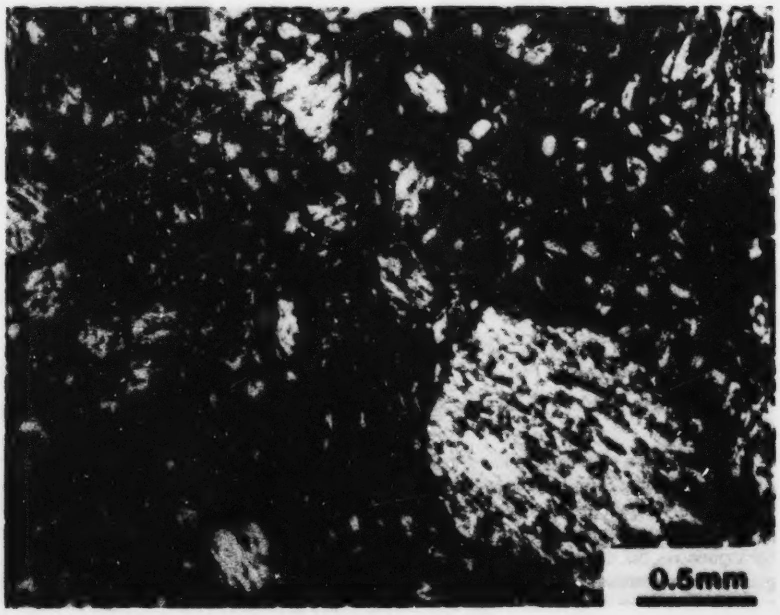


Plate 4: Tectonically brecciated layer (5 cm thick) within strongly foliated, laminated amphibolite (1h) south of Seller Lake. (Crossed nicols).

Bay. The Pain Killer Bay felsic volcanic body extends eastwards to the bay north of Omusinapis Point, which is underlain by felsic to intermediate volcanic fragmental rocks (2b); the felsic volcanic flows (2a$_1$) are apparently laterally transitional with the fragmental rocks, which extend approximately 14 km northeastwards and northwards, wedging out at the west shore of central Knee Lake. The felsic volcanic rocks are interpreted as conformable with older mafic volcanic rocks (1b, 1c, 1d) to the north, but the contact has not been observed.

Porphyritic rhyolite and dacite, minor related intrusions, pyroclastic rocks and minor mafic flows (2a$_1$)
Quartz-feldspar porphyry (2d)

The felsic volcanic flows range from rhyolite to dacite (Appendix A) and are fine grained to aphanitic; a flinty, conchoidal fracture is characteristic. Three phases have been recognized in the Pain Killer Bay felsic volcanic body, each with distinctive phenocryst contents (I to III, progressively younger phases — Table 4).

Flow brecciation occurs locally in lenses or irregular zones up to 4 m thick; the oligomictic breccias, containing pebble- to cobble-size clasts (up to 75 cm), are gradational with massive flows. Minor polymictic breccias (with porphyritic felsic and mafic volcanic clasts) have sharp contacts with the massive felsic volcanic rocks. The breccias have only been observed in the upper third of the felsic volcanic unit. The thickest fragmental zone, just west of Long Island, consists of at least 65 m of breccia (2a$_1$) with strongly flattened rhyolitic cobbles in a felsic tuff matrix.

Large pillows (up to 1 x 5 m) occur in a medium green, dacitic flow at the northwest shore of the bay west of Pain Killer Bay. The composition is inferred from the specific gravity (2.69 ± 0.015) which is in the dacite-rhyolite range for volcanic rocks at southern Knee Lake. Interpillow chert is characteristic, and the rock contains phenocrysts of plagioclase and subordinate quartz, dark chloritic lenticles (1 cm long) and accessory carbonate (approximately 8 per cent).

The felsic volcanic flows are moderately to well foliated; cataclastic layering with quartz stringers is developed in rhyolite at the east end of Long Island. Narrow concordant shear zones (0.3-1.5 m) within the flows are commonly silicified and/or carbonatized.

Minor intrusive phases occur in the southern part of the Pain Killer Bay felsic volcanic body, and less commonly in the central part (Table 4). Minor granodiorite intrusions within the flows at the north shore of Long Island are interpreted as synvolcanic on the basis of the close spatial relationship with the extrusive rocks and the lithologic similarity (e.g. pseudomorphs after hornblende occur in both the granodiorite and dacitic flows of phase III).

Quartz-feldspar porphyry dykes (2d) up to 5 m thick intrude mafic volcanic flows (1b, 1c, 1d) both north and south of the Pain Killer Bay felsic volcanic body, which is therefore interpreted to predate at least some of the dykes. The porphyries are commonly strongly foliated but are otherwise similar to flows of phase I except for the absence of microcline phenocrysts in most dykes. However, several porphyry dykes within variolitic basalt (1b$_3$) at Long Island contain microcline phenocrysts, together with sporadic basaltic xenoliths.

Contact relationships between the felsic volcanics (2a$_1$) and gabbro (1e) indicate these units are approximately contemporaneous. Gabbro at the northwest end of southern Knee Lake intrudes porphyritic rhyolite (Phase I) and contains rare xenoliths of the latter (Oxford House area, NTS 53L/14); however, a related gabbro sill on the large island to the east is intruded by a subhorizontal rhyolite porphyry interpreted as part of Phase I. Felsic volcanic rocks adjacent to serpentinized peridotite (1a$_2$) at the northwest end of southern Knee Lake have been strongly sheared and altered, probably as a result of the emplacement of the ultramafic rocks.

The felsic volcanic rocks contain quartz and feldspar phenocrysts (15-50 per cent of the rocks) in a very fine grained matrix of quartz, feldspar, sericite and sphene (± chlorite). Plagioclase phenocrysts are abundant and ubiquitous; quartz phenocrysts are subordinate to plagioclase, and absent in approximately 10 per cent of rocks of unit 2a$_1$; plagioclase phenocrysts exceed those of quartz by a ratio of approximately 3:1 (up to 20:1). Microcline phenocrysts are confined to flows of phase I (Table 4). Plagioclase and quartz phenocrysts are 0.1-1 cm

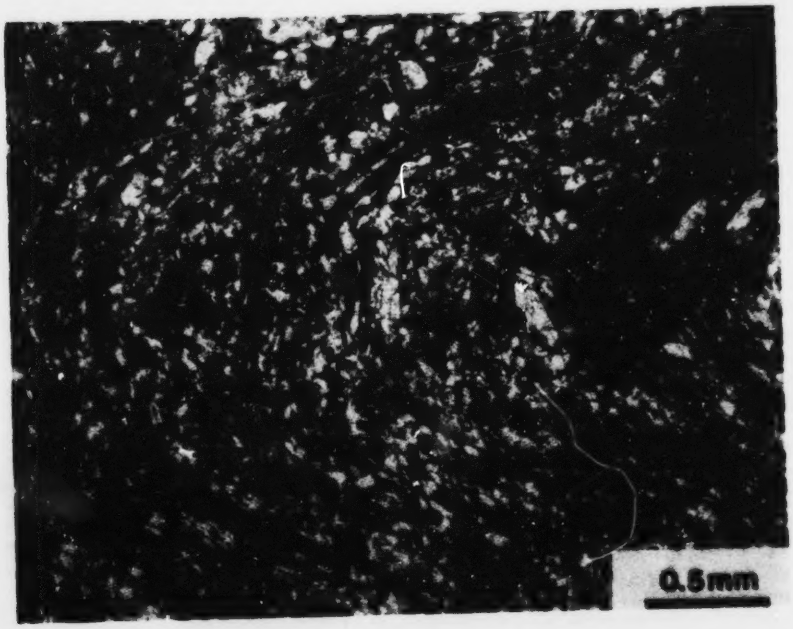


Plate 5: *Fine grained feldspathic greywacke (1h) with very fine, micaceous lamination, folded disharmonically (F$_3$ fold) from south of Seller Lake . (Crossed nicols).*

Table 4: Phases of flows and intrusive rocks of unit $2a_1$ at southern Knee Lake

PHASE	COMPOSITION	TYPE	WEATHERED COLOUR	APPROXIMATE PHENOCRYST CONTENT (per cent of total rock)			NOTES
				PLAGIOCLASE	QUARTZ	MICROCLINE	
I — Main phase (oldest)	rhyolite, dacite	flow, breccia, intrusive	generally cream, locally grey	15-35	5-15	0.30	locally pillowed
II	dacite	flow, intrusive	medium to dark grey to blue-grey	10-20	0-10	absent	
III	dacite		pale to medium grey	15-35	0-10	absent	contains euhedral hornblendes (partly to completely altered)

long and microcline 0.5-2 cm, up to 5 cm (Plate 6). Pyrite cubes (up to 1 cm) occur sporadically. Muscovite and hornblende are minor constituents. Euhedral green hornblende is locally prominent in minor intrusive phases related to the felsic volcanic flows. Accessories include epidote, clinozoisite, carbonate, pyrite and magnetite, biotite, apatite and zircon.

Plagioclase phenocrysts (generally albite, locally up to An_{35}) are euhedral to ovoid and commonly corroded. Twinning and oscillatory zoning are characteristic; zoning is best developed in phenocrysts within minor intrusions. Quartz phenocrysts are generally ovoid to amoeboid due to partial resorption; rare euhedral crystals occur sporadically. Straining or recrystallization to fine grained mosaics is common. Some phenocrysts are zoned, with embayed, clear cores and cloudy sericitic margins. Plagioclase and quartz phenocrysts in fragments within pyroclastic breccia ($2a_1$) are commonly broken and angular. Microcline phenocrysts are euhedral to ovoid (corroded), commonly perthitic and characterized by Carlsbad twinning (Plate 6). The microclines are generally poikilitic, with inclusions of quartz and corroded albite laths

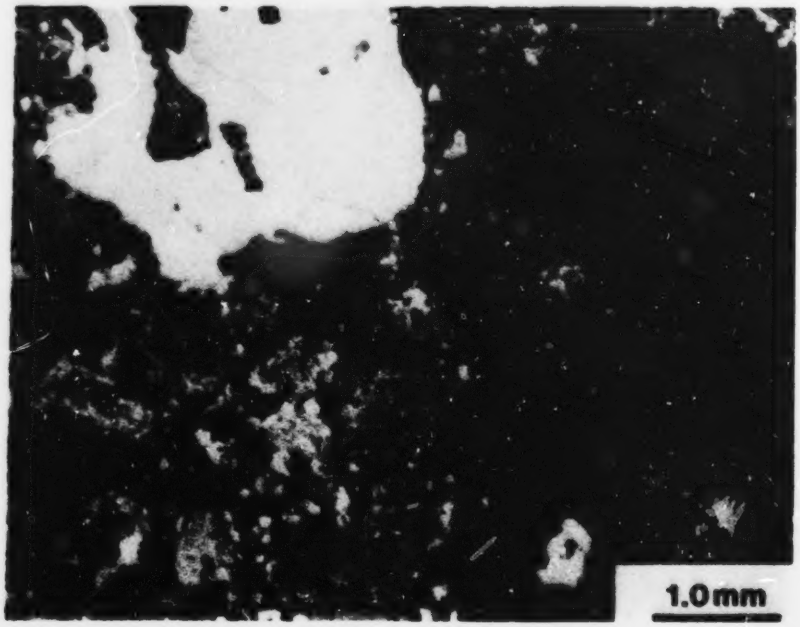


Plate 6: *Porphyritic rhyolite ($2a_1$) at southern Knee Lake containing phenocrysts of plagioclase and quartz (lower right), which occur as inclusions in the microcline phenocryst (at left). (Crossed nicols).*

which are locally aligned parallel to microcline cleavages. Muscovite is commonly poikiloblastic and partly altered to sericite or chlorite (± carbonate). Twinned green hornblende poikiloblasts are partly or completely altered to micaceous aggregates. Plagioclase phenocrysts and mafic minerals or their pseudomorphs are generally randomly distributed, but subparallel alignment of possible flow origin occurs in some units. Localized shearing of rhyolite is associated with rotation and/or granulation of feldspar phenocrysts.

Epidote and clinozoisite are widespread, and zircons up to 0.3 mm are common in most rocks of Phase I. Ilmenite, with sphene and leucoxene, occurs sporadically; blue to yellow-brown tourmaline and allanite are rare accessories. Minor chlorite is common in dacitic rocks, and accounts for their generally darker weathered surfaces compared to rhyolite. Saussuritization of plagioclase is variable (5-50 per cent, up to 100 per cent). Green hornblende is locally replaced by biotite or finer grained amphibole. Secondary carbonate is widespread (up to 30 per cent of the rocks) and disseminated or concentrated in the strain-shadows of phenocrysts. Intrusive rocks are similar mineralogically to related felsic flows, but are generally slightly coarser grained, with a tendency to subporphyritic texture; however, the matrix of some minor intrusions is very fine grained, as in the extrusive rocks.

Lithic fragments in breccia within the felsic volcanic flows are commonly more saussuritized than the breccia matrix. Clasts include felsic lithologies (of several types, distinguished by differences of porphyritic texture) and mafic, chloritic fragments with subparallel plagioclase laths.

The granodiorite at the north shore of Long Island is equigranular to subporphyritic, locally with plagioclase and minor microcline phenocrysts in a granophyric matrix. The mafic minerals are green hornblende (largely altered) and subordinate brown biotite. Minor, medium grained micrographic granite veinlets intrude the granodiorite. Quartzofeldspathic, epidotic, and carbonate veinlets (± chlorite ± muscovite) are common in both the granodiorite and the felsic volcanic rocks.

Felsic to intermediate volcanic fragmental rocks, minor rhyolite and sedimentary rocks (2b)

The volcanic fragmental rocks in the area east and northeast of Pain Killer Bay consist of pyroclastic breccia with subordinate interlayers (1-10 m thick) of tuff, felsic and mafic volcanic flows and related sedimentary rocks; the sequence is locally intruded by mafic dykes (8i). Pyroclastic breccia is generally polymictic, with essential felsic volcanic fragments, accessory intermediate and mafic clasts (grey to green) and sporadic accidental blocks of laminated chert. Felsic clasts are cream or pale grey, and contain phenocrysts of plagioclase and locally quartz and hornblende. The fragments, which constitute 60-80 per cent of the breccia, are predominantly subangular and pebble- to cobble-size; sorting is poor to absent. A distinctive oligomictic breccia (at least 25 m thick) outcrops just north of Omusinapis Point; angular, unsorted felsic fragments (1 cm-1 m across) occur in the clast-supported breccia, which is devoid of any matrix.

Tuff-breccia and crystal tuff interlayers occur within the pyroclastic breccias; crystal tuff contains abundant plagioclase laths and sporadic crystal aggregates, and minor subangular quartz grains in a very fine grained felsic to intermediate matrix. Sporadic, dark brown mafic cobbles occur in one felsic tuff deposit. The fragmental volcanic rocks vary from moderately to strongly foliated, with associated flattening of clasts. Shear zones (1-5 m wide) parallel to the regional foliation occur within the section.

Fine- to medium-grained, poorly bedded feldspathic greywacke comprises interlayers up to 5 m thick within the volcanic sequence, and minor cherty and argillaceous units occur northeast of Omusinapis Point. The metasedimentary rocks locally display flame-structures, scour-channels, cross-bedding, and graded bedding.

The base of the volcanic fragmental section is defined by a 25 m thick chert unit directly overlying pillowed basalt (1b$_2$). The chert is well layered (alternating cream and green laminae); the upper surface is scoured by the overlying pyroclastic breccia bed (18 m thick), which is succeeded by magnetiferous siltstone and chert iron formation (6 m thick); pyroclastic breccia (25 m thick) overlies the iron formation, which is locally incorporated as fragments in the breccia. Slumping or flow accompanying deposition of the breccia is indicated by one chert fragment which has been moved only a few centimetres from its place in the iron formation (Plate 7). Chert also occurs as thin interlayers within the pyroclastic breccia. The contact between the volcanic fragmental rocks (2b) and pillowed basalt (1b$_2$) to the north is discordant (by approximately 20°) to the regional trend of the mafic flows.

Felsic volcanic clasts in the pyroclastic breccia contain subhedral plagioclase (up to 5 mm), ovoid quartz phenocrysts, and minor chloritic aggregates in a very fine grained quartzofeldspathic matrix. Plagioclase (oligoclase to andesine) commonly displays oscillatory zoning. Mafic clasts are lithologically equivalent to basaltic flows of units 1b and 1c. The matrix of the pyroclastic breccia is felsic to intermediate, with subhedral to angular plagioclase microcrysts in a quartzofeldspathic matrix with biotite, muscovite, and accessory epidote, carbonate, magnetite and rare tourmaline. Crystal tuff interlayers within the fragmental section are similar to the breccia matrix.

Iron formation (2c)

Five iron formations have been mapped within the Hayes River Group at southern Knee Lake. The oldest and most northern unit, 6 m thick, occurs within basaltic flows (1b) northeast of Pain Killer Bay; the chert contains alternating dark magnetiferous and green siliceous laminae. Approximately 900 m above this unit a second formation occurs between the basalt and overlying reworked pyroclastic deposits (2b). The section from north to south at this locality consists of basalt (oldest) — white chert (20 m) — pyroclastic breccia (18 m) — iron formation (6 m) — reworked pyroclastic breccia (25 m) — intermediate crystal tuff (> 5 m). The iron formation comprises alternating magnetiferous siltstone and chert laminae (0.1-4 cm thick).

Approximately 1.2 km above the second iron formation a third unit (3 m thick) occurs at a reef in Oskatakak Narrows within a section of pillowed basalt (1b$_2$). Laminae of massive hematite (+ magnetite) and white chert (+ minor hematite, magnetite and carbonate) alternate at a scale of 0.1-2 cm, with sporadic thicker magnetiferous siltstone layers up to 10 cm. Hematite is the predominant iron oxide and appears to be an alteration product of magnetite. Minor pyrite stringers occur in the ferruginous laminae.

A fourth iron formation (1 m thick) occurs approximately 500 m above the third, at the west end of the large island south of Oskatakak Narrows. This unit occurs between pillowed basalt to the north and younger feldspathic greywacke and argillite (3f) to the south; the rock consists of alternating magnetiferous laminae of chert and slaty argillite. Sulphide facies iron formation occurs on-strike with this formation 3 km further east at the east end of the same island. Pyrite (partly altered to hematite) occurs within massive carbonate (+ minor quartz) in a tectonically brecciated zone at least 8 m wide. Iron stained siltstone in this zone contains pyrite stringers (0.1-1 cm) and irregular aggregates (up to 2 cm). Iron formation approximately on-strike with the fourth formation has been mapped further west (at the south shore of Long Island) between pillowed basalt (1b$_2$) to the north and the lower Oxford Lake Group volcanic complex (8) to the south. The formation contains chert, magnetite, and carbonate-rich chert laminae resulting in cream, grey and rusty weathering bands (0.1-1.5 cm wide); the lamination is partly disrupted and deformed in tight to isoclinal folds (Plate 8). Folding and/or brecciation is common in iron formations elsewhere at southern Knee Lake, reflecting their general incompetence.

Magnetiferous iron formation is associated with greywacke, argillite and minor conglomerate (3b) in a northwest-trending synclinorial body in the vicinity of Opischikona Narrows between southern and central Knee Lake. Iron formation occurs both at the margins and in the central part of the body, which is underlain by basalt (1b, 1c); the flanking

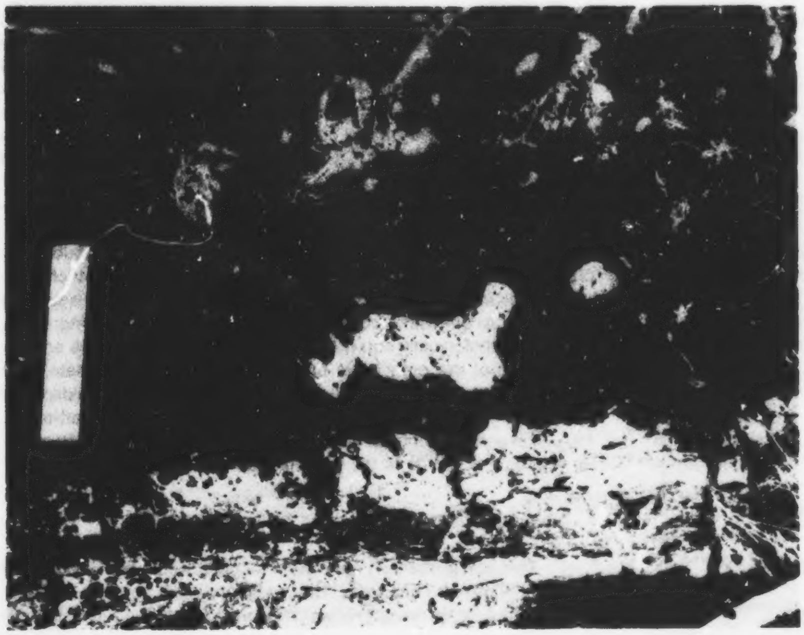


Plate 7: *Chert fragment displaced from substrate during deposition of pyroclastic breccia (2b) — north shore of southern Knee Lake. Length of ruler = 16 cm.*

Plate 8: *Magnetiferous iron formation (2c) of alternating chert and argillite laminae at Long Island, southern Knee Lake.*

iron formation thus marks the transition from mafic volcanism to greywacke deposition. The occurrence of iron formation in the central part of the synclinorium may represent a structural inlier of the basal flanking unit, or be part of a younger formation within the greywacke section. A prominent aeromagnetic anomaly is associated with the iron formation in this area (Map 4045G, Knee Lake, Federal-Provincial Aeromagnetic Series). The formation at Opischikona Narrows consists of interbedded magnetiferous and chert laminae (0.5-1 cm) with subordinate nodular chert horizons; these ovoid to irregular chert bodies are probably derived from originally gelatinous masses within the magnetiferous sediment.

Iron formation (2c) within gneissoid tonalite at the northwest shore of Michikinabish Lake is interpreted as a skialithic enclave of the Hayes River Group (Oxford House area, NTS 53L/14). Folded and dislocated magnetiferous chert layers (1-3 cm thick) alternate with hornblende-plagioclase gneiss (6c) over a 2 m section. Magnetite is randomly distributed or concentrated in fine laminae in the chert, which contains sporadic quartz grains (possibly detrital).

METAMORPHOSED VOLCANOGENIC SEDIMENTARY ROCKS AND MINOR VOLCANIC ROCKS (3)

Tuffaceous greywacke, minor graphitic argillite, tuffisite and pebble conglomerate (3b)

Tuffaceous sedimentary rocks and argillite comprise a synclinorial body in the vicinity of Opischikona Narrows (Knee Lake area, NTS 53L/15); minor pebble conglomerate, a thin (1 m) iron formation (2c) and several tuffisite intrusions occur within this section south of Magnetite Island. Contacts between this assemblage (3b) and older mafic volcanic rocks (1b, 1c) to the northeast and southwest have not been observed. The enclave of basalt (1b$_1$) within the sedimentary rocks (3b) immediately west of Opischikona Narrows is interpreted as a structural inlier. Amphibolite (1h) occurs on-strike with the sedimentary rocks in the area south of Seller Lake.

Dark grey tuffaceous greywacke is well layered (5-50 cm thick beds) and generally fine grained, locally with coarser grained lenses and graphitic argillite interlayers. The argillite is locally reworked into pebble conglomerate, which contains angular to ovoid fragments of felsic to intermediate volcanic rocks and quartz, and argillite rip-ups. Tuffisite is green to beige, with massive, pitted weathered surfaces, and traces of a steeply plunging lineation on vertical faces. The rock occurs as folded dykes and concordant layers up to 50 cm thick (Plate 9).

Tuffaceous greywacke units are interpreted as the subaqueous deposits of airborne ash, occurring as periodic influxes into a stagnant shallow water basin of deposition containing graphitic, pyritiferous argillite. The occurrence of tuffisite intrusions (''fossil-fumaroles'') are characteristic for ash-flows (Walker, 1971).

Tuffaceous greywacke contains subhedral to angular plagioclase (An_{10}) and angular quartz grains, argillite granules and sporadic porphyritic volcanic pebbles. Carbonate is a common accessory. Disseminated graphite occurs in the fine grained matrix, and graphite is abundant in the argillite granules and interbeds. The argillite also contains up to 5 per cent pyrite (disseminated or as lenticular aggregates) and accessory magnetite. The tuffaceous greywacke displays seriate texture (complete gradation from detrital plagioclase and quartz grains to the fine grained matrix). Lithic felsic fragments in one rock are corroded by the micaceous matrix, suggesting fluidization may have occurred during deposition.

Tuffisite consists of fine grained quartz, plagioclase, red-brown biotite (± chlorite), and carbonate (up to 15 per cent) with accessory muscovite, epidote, and rare tourmaline. The rocks contain sporadic aggregates (up to 1 cm) of fine grained mica and zircon interpreted as altered detrital fragments.

Feldspathic greywacke, minor argillite (3f)

Feldspathic greywacke with minor argillitic interlayers (3f) outcrops intermittently over a strike length of at least 19 km through southern Knee Lake; the unit attains a thickness of at least 380 m south of Omusinapis Point. The margins of this formation are locally coincident with a major shear zone, resulting in the occurrence of several minor inliers of greywacke (3f) interpreted as fault slices within younger pyroclastic rocks (8e) at the west end of the lake (Oxford House area,

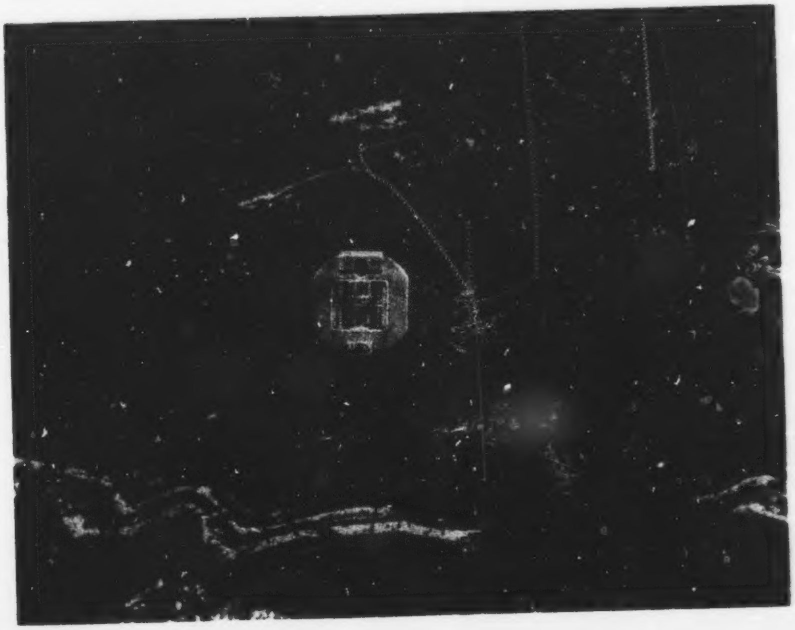


Plate 9: *Tuffisite intrusion (3b) in magnetiferous iron formation at the east end of southern Knee Lake.*

NTS 53L/14). Iron formation (2c) immediately underlies the greywacke (3f) at Long Island and at the island south of Oskatakak Narrows, where porphyritic pillowed basalt (1c$_2$) structurally overlies the greywacke. Further west, the feldspathic greywacke (3f) is overlain by volcanic rocks (8) to the south.

Feldspathic greywacke is beige to rusty brown (locally dark grey where graphitic) and layered at a scale of 8 cm to 1 m. Pebbly wacke at the base of some beds grades upwards to coarse grained greywacke. Pebble types include porphyritic felsic volcanics (predominant), basalt, quartz, siliceous siltstone, argillite, and feldspathic greywacke. Subordinate slaty argillite layers (1-5 cm thick) are partly reworked into the greywacke. Tightly folded, pyrite-bearing quartz veins occur sporadically in the formation.

The greywacke contains albite, quartz, and rare microcline grains in a fine grained, sericite-biotite-chlorite matrix (Plate 10). The detrital grains include euhedral and angular to subrounded forms; some quartz grains are embayed, indicating a volcanic provenance. Incipient porphyroblasts of biotite occur locally; accessories include carbonate, epidote, sphene, opaque minerals, tourmaline and zircon. Very fine grained graphite occurs in the greywacke south of Oskatakak Narrows.

Magill Lake Area

METAMORPHOSED MAFIC VOLCANIC AND RELATED SUBVOLCANIC ROCKS; MINOR ULTRAMAFIC ROCKS; MINOR SEDIMENTARY ROCKS (1)

Epidotized basalt; epidote amphibolite (1g)

Amphibolite, amphibolitic schist, minor feldspathic greywacke (1h)

Mafic volcanic rocks, amphibolite, and minor feldspathic greywacke (Plate 11) comprise a formation up to 800 m thick at the southern flank of the Oxford Lake-Knee Lake greenstone belt, extending along the northern margin of the gneiss complex (6a) south of Magill Lake. Similar rocks outcrop east of Magill Lake, in the southern part of Bayly Lake and in the northern part of Hawkins Lake (Vermilyea Lake, Munro Lake, Oxford House and Knee Lake areas, NTS 53L/10, L/11, L/14 and L/15, respectively). The contact between the amphibolite-greywacke unit (1g, 1h) and tonalitic gneiss (6a) south of Magill Lake is intrusive and/or faulted. In the southeastern part of McLaughlin Lake (formerly "Lake J")* these units are tectonically intercalated in a 300 m wide zone, and at Magill Creek the contact is marked by a thin (30 cm) pale green cataclasite derived from the tonalitic gneiss (6a) (Plate 12). The layered amphibolite in the Bayly Lake-Hawkins Lake area is interpreted as the tectonized margin of the basaltic terrane between these lakes (units 1b, 1c).

Amphibolite is predominant at the south margin of the formation (1g, 1h) between McLaughlin Lake and Brown Lake, and greywacke increases towards the north, where these rocks are in contact with Oxford Lake Group metasedimentary rocks (10a, 10f). At the north shore of Hawkins Lake, amphibolite and greywacke (1h) correspond to a minor aeromagnetic anomaly which curves northwards to Bayly Lake indicating continuity across the intervening drift-covered area with the amphibolite (1h) at southern Bayly Lake.

Lamination in the amphibolite, defined by variations of colour and grain size, is locally accentuated by the sporadic development of stratabound garnet and differential weathering. The amphibolite contains epidotic laminae (up to 2 cm) which locally coalesce to irregular masses and rare, thin (15 cm) concordant pyritiferous zones. Contacts between the amphibolite and feldspathic greywacke interlayers are generally gradational. The greywacke is medium to dark grey, fine grained, and locally contains thin pelitic laminae (Plate 11) and rare cherty interlayers.

Felsic stringers and lenses parallel to the foliation appear in some places to be derived from their host rocks by metamorphic segregation; elsewhere these are developed by attenuation of concordant granitoid veins. Sporadic, ovoid, cobble-size bodies of tonalite in feldspathic greywacke at McLaughlin Lake are interpreted as remnants of completely disrupted dykes. Boudinage and drag-folding of the host-rock layering

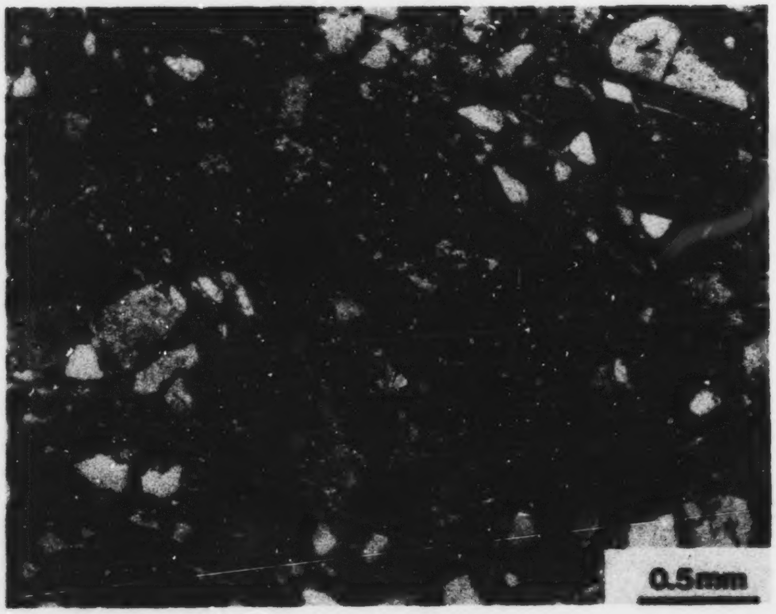


Plate 10: *Feldspathic greywacke (3f), comprised largely of volcanogenic quartz and plagioclase in a micaceous matrix; a porphyritic felsic volcanic granule occurs in the central to upper part of the photomicrograph — from southern Knee Lake. (Crossed nicols).*

---

*McLaughlin Lake is located close to the south margin of the Oxford House area (NTS 53L/14). The name does not appear on Map GR83-1-6, which was printed before the lake was officially named, but it is shown on Figure 2.

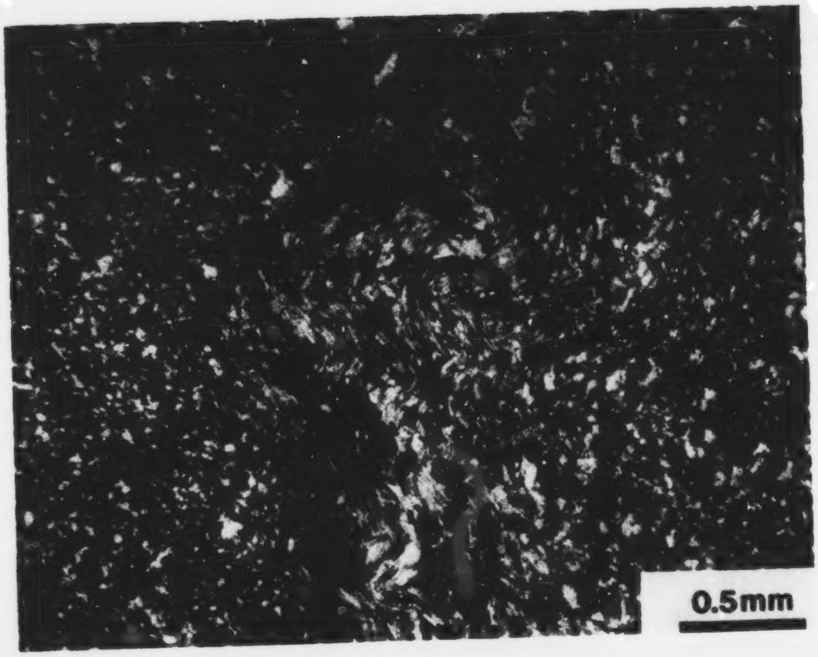


Plate 11: *Fine grained feldspathic greywacke (1h) from southern Magill Lake and thin pelitic lamination displaying microcrenulation and strain-slip cleavage (biotite-chlorite) associated with F_3 phase of deformation. (Crossed nicols).*

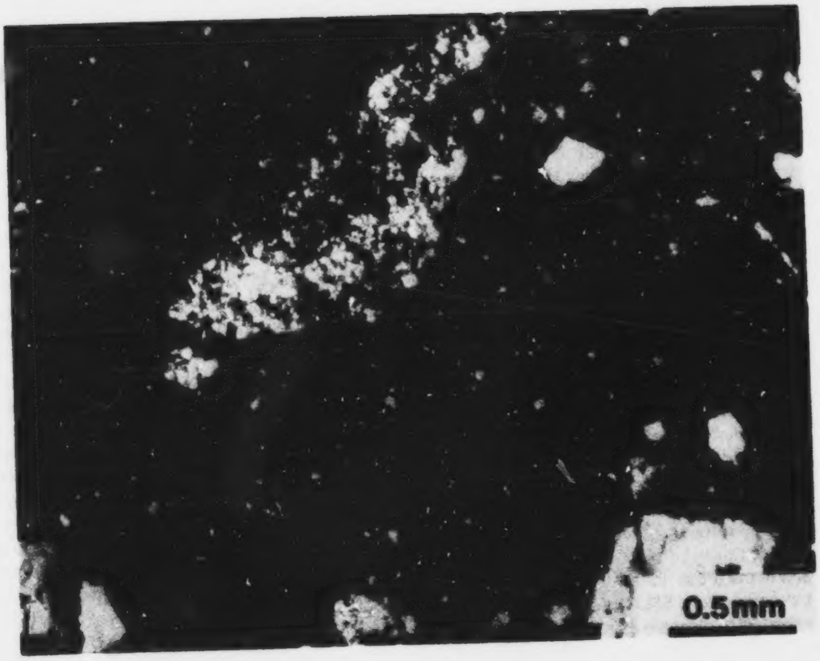


Plate 12: *Cataclasite (6d) at the north margin of the gneiss complex (6) at Magill Creek. Angular fragments derived from gneissoid tonalite occur in a very fine grained epidotic matrix. Sporadic fragments of mylonite within this matrix indicate more than one phase of deformation occurred in this zone. (Crossed nicols).*

are not uncommon. The well developed hornblendic foliation and lamination of amphibolite are locally microcrenulated, and truncated by epidotic veinlets of microbreccia. Epidote, chlorite and quartz veinlets postdate the deformation.

The amphibolites are similar mineralogically to equivalent rocks (1h) south of Seller Lake except for the occurrence of rare garnet, tourmaline, and allanite in the Magill Lake area. Amphibolites of both igneous and sedimentary origins occur in unit 1h. Petrographic evidence for ortho-amphibolites includes plagioclase oscillatory zoning and rare occurrences of lamellar structure in clinopyroxene. Zoned pyrite-epidote-magnetite aggregates, which were observed in several rocks, are similar to aggregates occurring in pillowed basalt ($1b_2$) in the Magill Lake area, indicating a possible genetic relationship. The local occurrence of massive unlayered amphibolite and common development of epidotic laminae are consistent with a volcanic origin; such features are characteristic of amphibolite (1h, 1g) at northeastern Gods Lake which is gradational with, and derived from, pillowed basalt (1b, 1c).

Amphibolites interpreted as tuffaceous or sedimentary contain up to 15 per cent quartz, and sporadic detrital grains of quartz, plagioclase, and rare apatite (as broken euhedral grains). These units are locally gradational with feldspathic greywacke.

Feldspathic greywacke contains detrital quartz, microcline, and plagioclase (albite to andesine) which constitute 10-25 per cent of the rock. The plagioclase grains are commonly crowded with very fine, ovoid quartz inclusions in a pseudo-myrmekitic texture, interpreted as metamorphic in origin. The very fine grained matrix varies from mafic (up to 50 per cent hornblende and/or biotite) to intermediate (less than 20 per cent mafic minerals). Biotite and chlorite locally define a weak strain-slip cleavage discordant to the bedding (Plate 11).

Gods Lake Area

METAMORPHOSED MAFIC VOLCANIC AND RELATED SUBVOLCANIC ROCKS; MINOR ULTRAMAFIC ROCKS; MINOR SEDIMENTARY ROCKS (1)

Basalt, minor andesite, related sills, minor basic tuff (1b)

Porphyritic andesite and basalt, minor dacite and related sills (1c)

Megaphyric andesite, basalt, and related minor intrusions (1d)

Mafic flows and related gabbro comprise the major part of the volcanic section (approximately 10.5 km thick) in the vicinity of Elk Island (Gods Lake area, NTS 53L/9). The base of the section is intruded by granitoid rocks (7b) south of Elk Island and the top is unconformably overlain by boulder conglomerate (9b) approximately 3 km north of Jowsey Island.

The mafic volcanic flows at Gods Lake, which are similar to those at southern Knee Lake, are largely pillowed and contain subordinate gabbroic sills (1e) and thin metasedimentary interlayers (3e). Pillows are typically densely packed with little or no inter-pillow detritus, but inter-pillow chert and felsic fragments occur at a few places. Rare pillow breccia ($1b_5$) occurs sporadically within the flows. One outcrop on the peninsula southwest of Yellowback Island is characterized by small discrete pillows and angular fragments in a comminuted matrix of amygdaloidal basalt (Plate 13); alteration and carbonatization are associated with the breccia (Yellowback Island area, NTS 53K/13). Similar breccia occurs 2 km northwest of the west end of Hopkins Lake (Gods Lake area, NTS 53L/9).

Quartz-amygdaloidal pillowed basalt ($1b_4$) occurs at the peninsula southwest of Yellowback Island, in the northern part of Elk Island, and in the areas northwest of Elk Island and west of Green Island (Gods Lake area, NTS 53L/9). Amygdales (1-3 mm diameter, up to 3 cm) are spherical to elongate (pipe-amygdales); they are commonly concentrated peripherally and radially disposed in the pillows. Some flows contain vesicles similar in form and distribution to the amygdales. Rare, parallel vesicle trails locally define a flow layering in massive basalt. Irregular open vugs occur in the cores of some pillows. Variolites (0.5-1 cm in diameter) occur in pillowed basalt ($1b_3$) in the area west of Graveyard Bay. Minor epidotic alteration occurs throughout the area, generally in pillow cores.

Plate 13: Pillow breccia ($1b_5$) within amygdaloidal pillowed basalt at northeastern Gods Lake.

Concentric, polygonal structures occur within irregular pillows 2.5 km northwest of the west end of Hopkins Lake (Plate 14). The structures are defined by differential weathering of narrow carbonatized zones which alternate with unaltered zones at a scale of 0.5-2 mm. Concentric patterns of alternating hornblendic/feldspathic zones (1-2 mm thick) in pillows north of Buyers Point are interpreted as cooling features (McIvor Lake area, NTS 53L/16).

Porphyritic flows (1c) contain plagioclase phenocrysts (1-10 mm) constituting 10-30 per cent of the rock (Plate 15). The phenocrysts are generally randomly distributed, but locally concentrated towards pillow margins. Megaphyric flows (1d), with phenocrysts 1-3 cm, contain pseudohexagonal plagioclase; these flows are less common at Gods Lake than in the section at southern Knee Lake.

Mafic flows are massive to poorly foliated and strongly sheared in narrow zones (1-5 m), commonly at contacts between the flows and gabbroic sills, granitoid dykes, or thin sedimentary units. Shearing is intensified in the axial zone of the northeast-trending syncline north of Elk Island (Gods Lake area, NTS 53L/9). Quartz, carbonate, pyrite and/or epidote veins are commonly associated with shearing. A thin epidote-rich mylonite unit (at least 50 cm thick) occurs within the prominent northwest-trending topographic lineament transecting northern Elk Island.

Plate 14: *Polygonal structures (cooling fractures?) in amygdaloidal pillowed basalt ($1b_4$) at Gods Lake.*

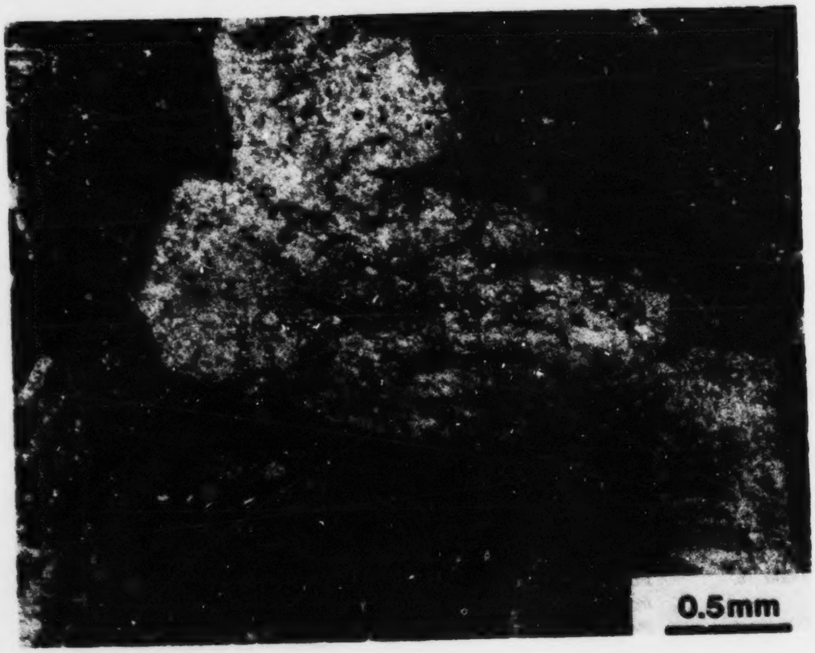


Plate 15: *Plagioclase phenocrysts in a basaltic matrix containing plagioclase microlites — from pillowed porphyritic basalt ($1c_3$) at Gods Lake. (Plain light).*

The contacts between the mafic volcanics and granitoid rocks (4, 7) are generally sharp, locally agmatitic or cataclastic. Contact metamorphism has locally resulted in green hornblende porphyroblasts and rare clinopyroxene-sphene aggregates in basalt. Plagioclase porphyroblasts are developed in basalt (Plate 16) near the contact with tonalite (4a) east of Hurley Island (Yellowback Island area, NTS 53K/13).

The mafic flows at Gods Lake consist largely of green hornblende (or tremolite) and andesine-labradorite. Plagioclase laths (up to 1 mm long) in the matrix locally display "swallow-tail" terminations and central trails of epidote or tremolite, a feature which is interpreted as a quench texture by Pearce (1974). Plagioclase phenocrysts are locally arranged in synneusis structure (Vance, 1969). Amygdales of very fine grained quartz (± plagioclase) are locally rimmed by chlorite (± epidote). Pillow selvages are generally epidotic, commonly with hornblende-rich margins.

The mafic volcanic rocks are interpreted as subaqueous flows; no evidence for subaerial extrusion has been recognized. The occurrence of massive, non-pillowed flows within pillowed sections is attributed to relatively rapid extrusion which did not allow for pillow development, as described by Snyder and Fraser (1963). The occurrence of vesicles and amygdales indicates shallow to medium depth (less than 2 km) but the absence of conspicuous zoning of pillows suggests at least 400 m depth according to Jones (1969). Variolitic flows at northeastern Gods Lake are possibly the deepest in the section, since variolites in nonvesicular basalt have been taken to indicate relatively high hydrostatic pressure (Furnes, 1973). The mafic volcanic sequence is relatively homogeneous throughout; accommodation of the thick flow section may be accounted for by contemporaneous subsidence.

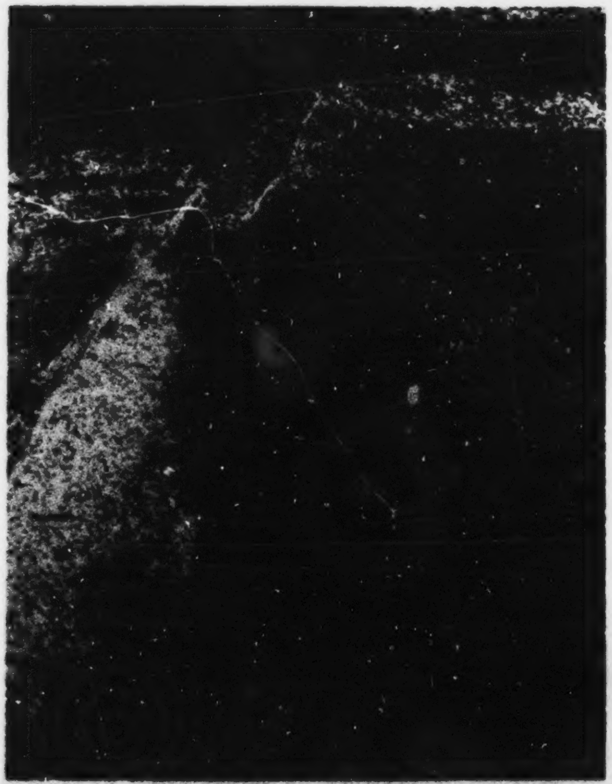


Plate 16: Porphyroblastic plagioclase in basalt ($1b_3$) resulting from contact metamorphism by tonalite (4b) at northeastern Gods Lake.

Equigranular gabbro ($1e_1$)
Porphyritic gabbro ($1e_2$)
Mesocratic porphyry, quartz gabbro, granophyre ($1e_4$)

Gabbro sills are common within the mafic flows or emplaced between basalt and minor sedimentary units (3e) within the volcanic section. The large sill 3 km north of Elb Lake (on Elk Island) is gradational northwards into pillow basalt; the southern margin of the sill is in contact with iron formation. Chilled margins (up to several metres wide) are common in the gabbros. Xenoliths within the sills are rare but several enclaves of granite occur in one body close to the southwest end of Yellowback Island.

The gabbro sill immediately north of Margaret Lake (on Elk Island) is flanked by narrow (< 6 m) tuff beds. The northern tuff is host to the sulphide-gold ore formerly mined by Gods Lake Gold Mines Limited (Baker, 1935). The outlines of this sill and the larger intrusion to the north, as shown on Map GR83-1-13, are taken from Dix (1951).

The gabbros at Gods Lake are similar to equivalent intrusions at southern Knee Lake, except for the more common occurrence of hornblendite phases (> 90 per cent hornblende) and rare occurrences of stilpnomelane in the sills at Gods Lake. Disseminated or strata-bound plagioclase phenocrysts (0.5-3 cm) occur in some intrusions; these locally constitute up to 80 per cent of anorthositic gabbro layers up to 75 cm thick (e.g. in the sill 3 km north of Elb Lake). Plagioclase megacrysts and aggregates up to 15 cm in diameter occur in one sill close to the northwest end of Yellowback Island (Plate 17). Some sills consist of two or more gabbroic phases; late quartz gabbro and/or granophyric phases occur in some intrusions. Quartz veins occur locally in the sills; assayed samples yielded up to 0.03 per cent Cu, 0.02 per cent Zn and traces of Ni and Au.

Mafic to intermediate pyroclastic rocks, minor greywacke, argillite and basalt (1f)

Mafic to intermediate lapilli-tuff and pyroclastic breccia interlayers (5-10 m thick, up to 50 m) occur within amphibolite (1h) at the northeast shore of Johnson Bay (northern Gods Lake). Lapilli and bombs (up to 3 x 30 cm) constitute 20-50 per cent of the rocks; the felsic to intermediate fragments (cream to medium grey) occur in an amphibolitic, medium to dark green or grey matrix which locally contains garnetiferous stringers and porphyroblasts (up to 3 mm) and sporadic hornblendic or chloritic aggregates. Quartzofeldspathic and minor hornblendic stringers and veinlets are characteristic. The matrix consists of green hornblende and plagioclase with accessory magnetite, quartz and sphene. Minor carbonate microveins and fine chloritic partings occur in some rocks. Traces of an original detrital texture (subangular plagioclase microcrysts) are locally preserved, but generally the fragmental rocks are strongly foliated and primary textures are not preserved.

Epidotized basalt, epidote amphibolite (1g)
Amphibolite, amphibolitic schist, minor feldspathic greywacke (1h)

Amphibolitic rocks (1g, 1h) comprise the major part of the section at Johnson Bay, northern Gods Lake (McIvor Lake area, NTS 53L/16), and occur in the vicinity of Yellowback Island, northwestern Gods Lake (Yellowback Island area, NTS 53K/13). The amphibolitic rocks (1g, 1h) are commonly associated with mafic volcanic flows.

The amphibolites are similar to equivalent rocks south of Seller Lake except for sporadic garnet and stilpnomelane occurrences at Gods Lake. Lamination (1-20 mm) in these rocks is defined by variable hornblende/plagioclase ratios and concordant epidotic stringers, which are locally recognized as derived from pillow basalt selvages where flows within the section are gradational with the laminated amphibolite (Plate

18). Zoned quartz amygdales with clinozoisite rims within some amphibolite units at Buyers Point also indicate derivation from mafic flows. Minor mafic sills (1-5 m) with chilled margins occur within amphibolite at Johnson Bay.

The development of amphibolite from altered basalt (and possible mafic tuff) at northern Gods Lake is a result of increased strain and metamorphism towards the margins of the greenstone belt where it is intruded by younger granitoid rocks of the Bayly Lake Complex (4, 7). These areas are characterized by abundant dykes of tonalite, granodiorite and felsic porphyries, which have locally resulted in hornblende porphyroblastesis in the adjacent mafic rocks. The lamination of the amphibolite (1h) is locally boudinaged and folded by later deformation associated with a chloritic strain-slip cleavage (Plate 19).

METAMORPHOSED FELSIC VOLCANIC, SUBVOLCANIC AND RELATED SEDIMENTARY ROCKS (2)

Felsic to intermediate volcanic fragmental rocks, minor rhyolite and sedimentary rocks (2b)

Crystal tuff, and minor pyroclastic breccia and amphibolite comprise a unit up to 670 m thick and at least 1.3 km long northwest of Buyers Point (McIvor Lake area 53L/16). The pyroclastic breccia contains felsic to intermediate volcanic clasts (pebble- to cobble-size) in an intermediate to mafic matrix. Clasts are locally highly attenuated, with associated development of tectonic layering. Minor laminae (1-10 mm) of amphibolite (± garnet) and rare thicker mafic units (up to 1.5 m) within the fragmental rocks are locally boudinaged.

The felsic to intermediate crystal tuff consists essentially of subhedral albite, quartz, and brown biotite. Lenticles and fine grained aggregates of quartz are probably derived from original detrital grains. Partly chloritized biotite is locally closely associated with magnetite, which constitutes up to 5 per cent of the tuff. Minor hornblende occurs parallel to the micaceous foliation or in sporadic radiating aggregates. Epidote, carbonate and allanite are common accessories. Intermediate tuff is characterized by thin (1-10 mm) mafic laminae which consist of biotite and hornblende or muscovite and zoisite. Concordant quartz stringers and late discordant epidotic veinlets are common.

Iron formation (2c)

Magnetiferous iron formations occur close to the northwest shore of Elk Island, and at two localities at northeastern Gods Lake, south of Yellowback Island (Gods Lake, Pesanapisko Lake and Yellowback Island areas: NTS 53L/9, 53K/12 and K/13, respectively). These units have been intruded by gabbro (at Elk Island) and quartz-feldspar porphyry (south of Yellowback Island). Prominent aeromagnetic anomalies are associated with the iron formations, locally outlining the major anticline south of Yellowback Island (Maps 3660G and 3661G, Federal-Provincial Aeromagnetic Series).

The iron formations are 0.5-3 m thick, and consist of well layered chert, magnetite, argillite and/or amphibolite. Magnetite is finely disseminated or occurs as sporadic larger grains or is concentrated in fine laminae. The formation 5 km south of Yellowback Island is characterized by ovoid structures (1-3 mm), of magnetite (± quartz) rimmed by green hornblende, which are concentrated in magnetiferous layers within the alternating chert/amphibolite/carbonate sequence (Plate 20). This formation also contains cross-bedded greywacke interbeds up to 30 cm thick. Primary folding and sedimentary microfaults are locally preserved (Plates 21 and 22).

A volcanic exhalative origin is interpreted for the iron formations at southern Knee Lake and Gods Lake; these occur within mafic volcanic flow sections or between volcanic flows and overlying volcanic fragmental or sedimentary units. Gross (1965) has classified these iron formation types as "Algoman" and suggested a well aerated, shallow water depositional environment for the oxide facies of this category. Precipitation of silica and iron oxide(s) of probable exhalative origin was accompanied by deposition of greywacke and argillite. The ovoid bodies in the formation south of Yellowback Island (Gods Lake) may result from precipitation and accretion; however, the local occurrence of partly joined, twinned bodies (Plate 20) supports a post-depositional origin. Sulphide facies iron formation east of Oskatakak Narrows (southern Knee Lake) is attributed to a localized quiet water, reducing environment with restricted

Plate 17: *Megaphyric gabbro ($1e_2$) from northeastern Gods Lake.*

Plate 18: *Attenuated pillows in porphyritic basalt ($1c_2$), northeastern Gods Lake; the structure represents an intermediate stage in the development of layered amphibolite from pillowed flows.*

Plate 19: *Finely laminated amphibolite (1h) with drag-folds, northern Gods Lake.*

Plate 20: Ovoid structures of green hornblende in magnetiferous laminae of iron formation (2c), northeastern Gods Lake. (Crossed nicols).

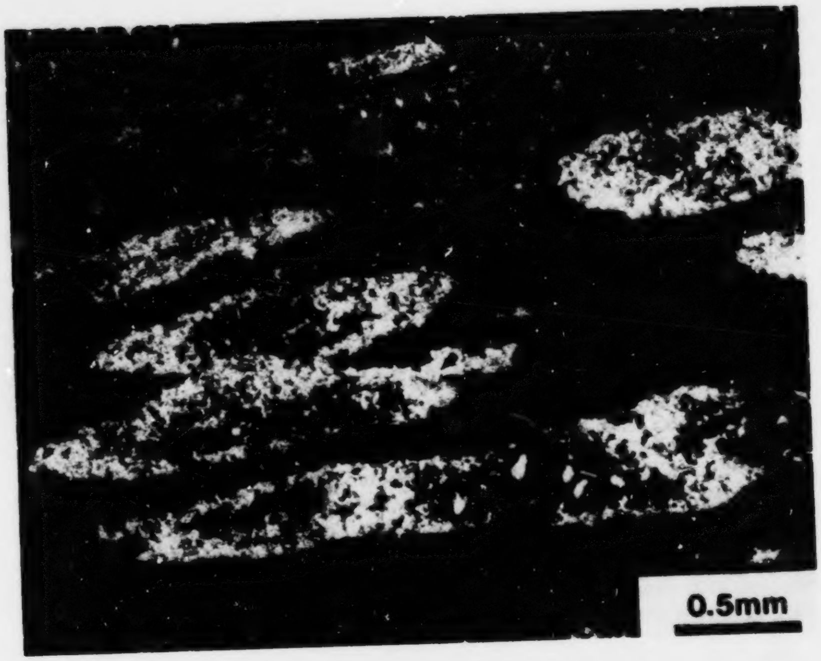


Plate 21: Primary folding and disruption of fine lamination in siltstone associated with iron formation (2c), northeastern Gods Lake. (Crossed nicols).

Plate 22: Sedimentary microfaults in magnetiferous iron formation (2c) close to Elk Island, Gods Lake. (Crossed nicols).

circulation; these conditions also existed during deposition of graphitic and argillitic members in the overlying sedimentary rocks (3f).

METAMORPHOSED VOLCANOGENIC SEDIMENTARY ROCKS AND MINOR VOLCANIC ROCKS (3)

Greywacke, tuff, minor intermediate and mafic flows and volcanic fragmental rocks (3a)

Interlayered sedimentary rocks and volcanic breccia, tuff and flows occur at western Gods Lake in the vicinity of Billys Hole Island and at islands approximately 1-4 km east and northeast of Kichenaonan Point, and close to the northeast extremity of Elk Island (Gods Lake area, NTS 53L/9). The unit northeast of Elk Island occupies the core of a northeast-trending syncline, overlying the mafic volcanic flows (1b, 1c) in that area. At western Gods Lake, the rocks of unit 3a occur in an anticlinal structure.

GREYWACKE

Greywacke is generally intermediate, fine- to medium-grained, with biotite predominant over hornblende. Bedding (at 1-30 cm) is defined by compositional and colour variations (grey, grey-green or beige); rare graded bedding is also developed. Minor pebble-beds contain mafic, felsic and epidotic fragments. Detrital quartz and plagioclase grains are locally prominent northeast of Elk Island, but the rocks at western Gods Lake are generally more recrystallized with the loss of most primary textures.

The micaceous foliation at western Gods Lake is locally overprinted by porphyroblasts of green hornblende, garnet, staurolite, andalusite, muscovite, biotite, chlorite and rare cummingtonite (the latter in magnetiferous greywacke). Porphyroblasts are generally randomly oriented except for andalusite which is parallel to the foliation; several occurrences of anthophyllite define a later incipient foliation discordant to the earlier fabric. The porphyroblasts are variously altered to micaceous aggregates (up to 3 cm) which occur sporadically or in layers. Biotite is locally altered to prehnite and/or chlorite. Late granulation and saussuritization occur in 1-10 cm wide zones parallel to the foliation. Accessory minerals include sphene, apatite, carbonate, magnetite, pyrite and rare zircon and tourmaline.

The following mineral assemblages occur in metasedimentary rocks at western Gods Lake:

1. Garnet-anthophyllite-biotite-quartz-plagioclase
2. Anthophyllite-biotite-quartz-plagioclase
3. Staurolite-biotite-quartz-plagioclase
4. Muscovite-biotite-quartz-plagioclase
5. Hornblende-quartz-plagioclase ± biotite
6. Andalusite-muscovite-rutile-quartz-sulphides

Plagioclase composition is andesine to labradorite.

VOLCANIC FRAGMENTAL ROCKS

Poorly bedded, intermediate to mafic tuff, crystal- and lapilli-tuffs are interlayered with pyroclastic breccia at a scale of 0.5-10 m. The breccia contains poorly sorted, pebble- to cobble-size fragments which are subangular to subrounded and commonly well attenuated. Clast types include felsic volcanics (± plagioclase phenocrysts), plagioclase-phyric andesite, epidosite, quartz, and amphibolite (fine- to medium-grained, ± plagioclase phenocrysts ± hornblende pseudomorphs).

INTERMEDIATE AND MAFIC FLOWS

Minor intermediate flows (up to 5 m thick) are interlayered with porphyritic basalt close to the west end of Billys Hole Island. These are pale- to medium-beige to grey, and contain plagioclase phenocrysts (albite to andesine) and subordinate, partly corroded, quartz phenocrysts. Euhedral hornblende crystals are partly altered to biotite; calcic pseudomorphs (epidote-sphene-carbonate ± chlorite) may be derived from hornblende. Minor accessories include apatite, sphene, muscovite and magnetite.

Intermediate quartz-plagioclase porphyry dykes (0.3-1 m thick) of at least two ages occur at western Gods Lake. The older phase is similar petrographically to the dacite and also to some fragments within the pyroclastic breccia (3a) and a synvolcanic age of intrusion is inferred. The younger porphyries postdate the regional foliation and are interpreted as unit 7g intrusions.

Mafic flows and related gabbro occur within unit 3a at western Gods Lake. The flows are generally well foliated to gneissic, and evidence of pillows consists of rare selvage remnants only. Associated gabbros (0.5-5 m thick) are medium- to coarse-grained amphibolites, locally micaceous, with lineated hornblende porphyroblasts and sporadic garnets; plagioclase phenocrysts (andesine to labradorite) occur in some of the mafic flows and sills.

ZONES OF SHEARING AND MINERALIZATION

Shear zones, up to 2 m wide, are associated with horizontal displacements of up to 8 m in rocks of unit 3a just north of Billys Hole Island. Talc schist (± chlorite ± carbonate ± andalusite) occurs in these zones. Sulphides are locally concentrated in schist adjacent to amphibolitic laminae, or in calc-silicate interlayers. Pyrite, chalcopyrite and subordinate sphalerite stringers constitute up to 10 per cent of these rocks; one assayed sample yielded 0.05 per cent Cu, 0.02 oz./ton Au, and a trace of Zn.

Feldspathic greywacke, minor pebble conglomerate, siltstone, chert and tuff (3e)

Minor interlayers of fine grained sediment and tuff (3-10 m thick) occur sporadically within mafic flows (1b, 1c) in the Gods Lake area. Thicker sedimentary sections (up to 200 m) are developed in the core of the northwest-trending syncline at northern Elk Island, and at islands northeast of Elk Island. The thinner formations are typically strongly foliated, but thicker sections are less deformed and primary structures are commonly well preserved. Synvolcanic gabbros (1e) have locally been emplaced at the margins of minor sedimentary interlayers within mafic volcanic sections.

Feldspathic greywacke is grey to beige, massive or well layered (1-20 cm beds). The rock contains subangular detrital grains of quartz, albite and subordinate microcline in a micaceous (locally hornblendic) siltstone matrix. Sporadic hornblende porphyroblasts are partly altered to micaceous aggregates. Subordinate interlayers of pebble conglomerate and siltstone (up to 30 cm) and minor cherty interbeds (up to 8 cm) occur locally. Siltstone rip-ups (Plate 23) and sporadic pebbles occur in sections containing conglomerate interbeds. Angular to subangular pebbles in the sediments include felsic to mafic volcanics (commonly with plagioclase phenocrysts and/or hornblende microcrysts), mafic and cherty siltstone, feldspathic greywacke and possible tuff. Graded bedding, flame structures and scoured channels (up to 1.2 m deep) with associated cross-bedding are locally developed (Plate 24). Primary folding and faulting occur at a few places.

Minor felsic tuff interlayers (up to 50 cm thick) within pillowed basalt ($1b_2$) contain angular quartz and subhedral plagioclase microcrysts and epidotic, devitrified glass shards (Plate 25). Some beds contain fine stringers and laminae (1-10 mm) of graphite or epidote. Dark, brown-grey mafic tuff also occurs within the mafic flows and is locally interlayered with chert. Characteristic "scalloped" weathered surfaces in the mafic tuff, similar to the appearance of limestone, are probably due to the presence of carbonate. Reworked intermediate crystal tuff in the core of the syncline at northern Elk Island is devoid of layering and contains detrital plagioclase, granules of felsic and mafic volcanics, chert and quartz, and sporadic, irregular aggregates of hornblende and plagioclase crystals (Plate 26).

The thin sedimentary and tuffaceous interlayers (3e) within pillowed basalt represent ephemeral periods of deposition of volcaniclastic and cherty sediments within an essentially continuous sequence of mafic volcanic flows. Feldspathic greywacke and conglomerate display features consistent with a proximal turbidite environment (Walker, 1967) and these rocks were probably rapidly deposited on the steep flanks of the mafic volcanic pile accounting for their load structures and penecontemporaneous deformation. Finely laminated tuffs and chert probably accumulated in still waters where turbiditic flows were not active.

Feldspathic greywacke, minor argillite (3f)

Well bedded greywacke and argillite outcrop sporadically along Gods River in the northern part of the Semmens River area (NTS 53N/4).

Plate 23: *Interlayered feldspathic greywacke and siltstone (3e) display graded bedding, flame-structures, and disruption of pale siltstone beds near Elk Island, Gods Lake.*

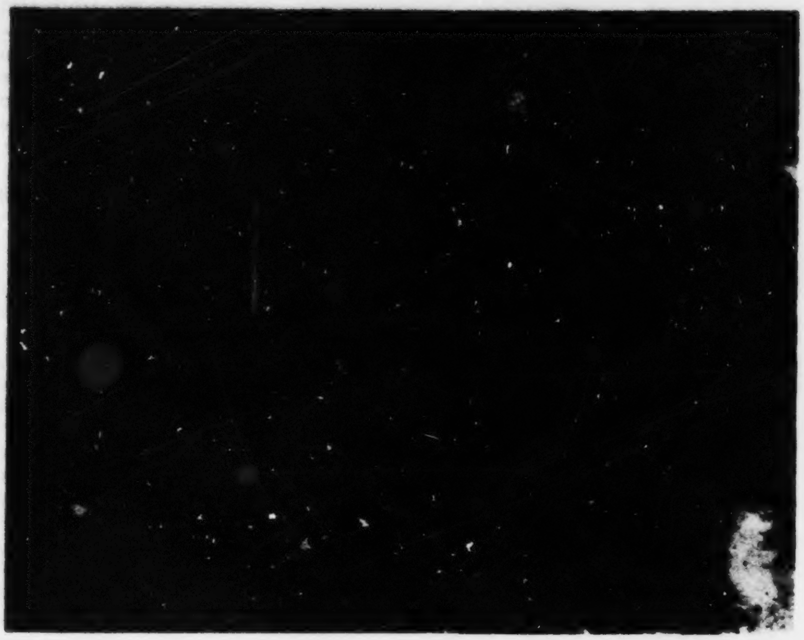


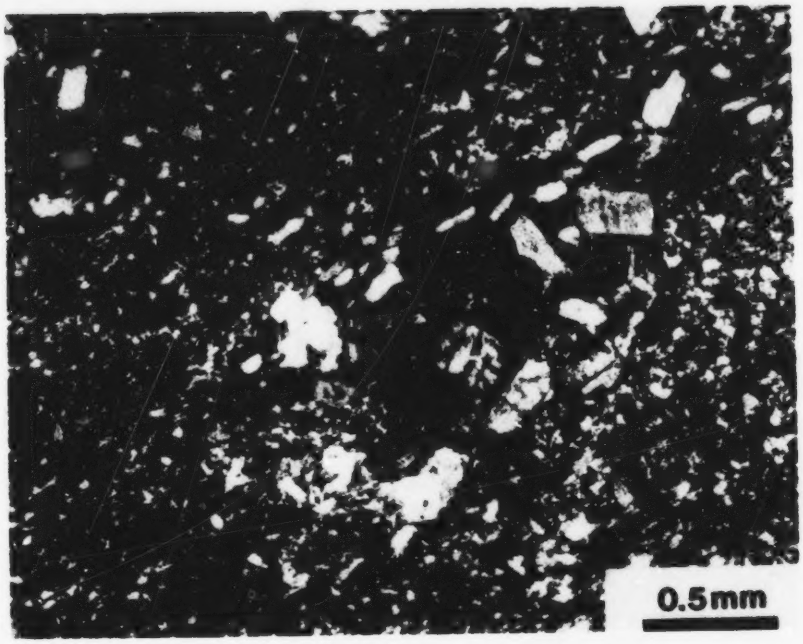
Plate 24: *Channel deposit in medium- to coarse-grained feldspathic greywacke-siltstone sequence (3e) with graded bedding and truncated primary folds. Lineations oblique to bedding are glacial striations. Location near Elk Island, Gods Lake (same as Plate 22).*

Plate 25: *Vitroclastic texture of devitrified glass shards in a fine grained matrix of quartz, clinozoisite, carbonate and sericite — in a 30 cm thick felsic tuff layer (3e) within pillowed basalt near Elk Island, Gods Lake (Plain light).*

Graded bedding and cross-bedding occur locally in the dark grey to beige greywacke, which is interlayered with argillite at a scale of 10-50 cm. The greywacke contains angular to subrounded detrital quartz and plagioclase, and porphyritic felsic volcanic granules (Plate 27). The section faces northeast and apparently comprises the southern limb of a synclinal structure - similar rocks face south and southeast at Sturgeon Falls, approximately 3 km north of the northern boundary of the Semmens River area.

The sedimentary rocks at Gods River may be correlated by utilizing aeromagnetic trends with similar rocks at Red Cross Lake, approximately 40 km to the east. Prominent aeromagnetic anomalies exceeding 8500 gammas are associated with the sedimentary rocks in both areas indicating the probable occurrence of extensive magnetiferous iron formation in the section (Map 7133G, Gods River, Federal-Provincial Aeromagnetic Series). These rocks are interpreted as part of the Hayes River Group because the major iron formations in the Knee Lake-Gods

Plate 26: *Crystal aggregate of plagioclase and hornblende adhering to very fine grained (originally vitreous?) body in intermediate crystal tuff (3e) at Gods Lake. (Crossed nicols).*



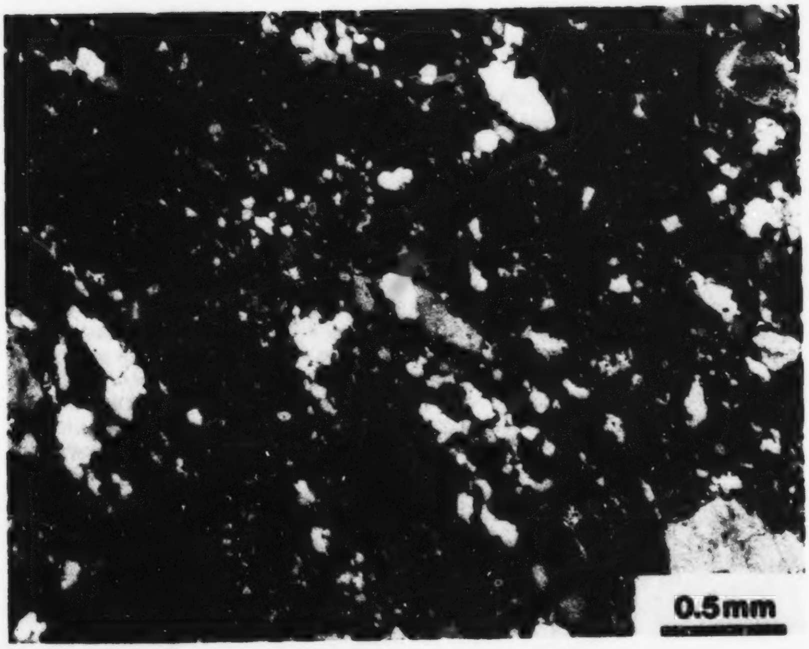


Plate 27: *Feldspathic greywacke (3f) with quartz, feldspar, and porphyritic felsic volcanic fragments in a biotite-bearing matrix — from Sturgeon Falls, Gods River. (Crossed nicols).*

Lake greenstone belt are of this age. Furthermore the greywacke at Gods River in the northern part of the Semmens River area is compositionally and texturally similar to some Hayes River Group rocks (compare Plates 10 and 27). This interpretation is consistent with regional stratigraphic relationships (Weber, pers. comm.). The sediments at Red Cross Lake, however, were assigned to the Oxford Lake Group by Potter (1962) and Sopuck (1971); their conclusions were based partly on the occurrence of granite-cobble conglomerate at Red Cross Lake and at Shorty Rapids (1.5 km south of Sturgeon Falls) on Gods River (Potter, op. cit.). Possibly both Hayes River and Oxford Lake Group rocks are present in this area.

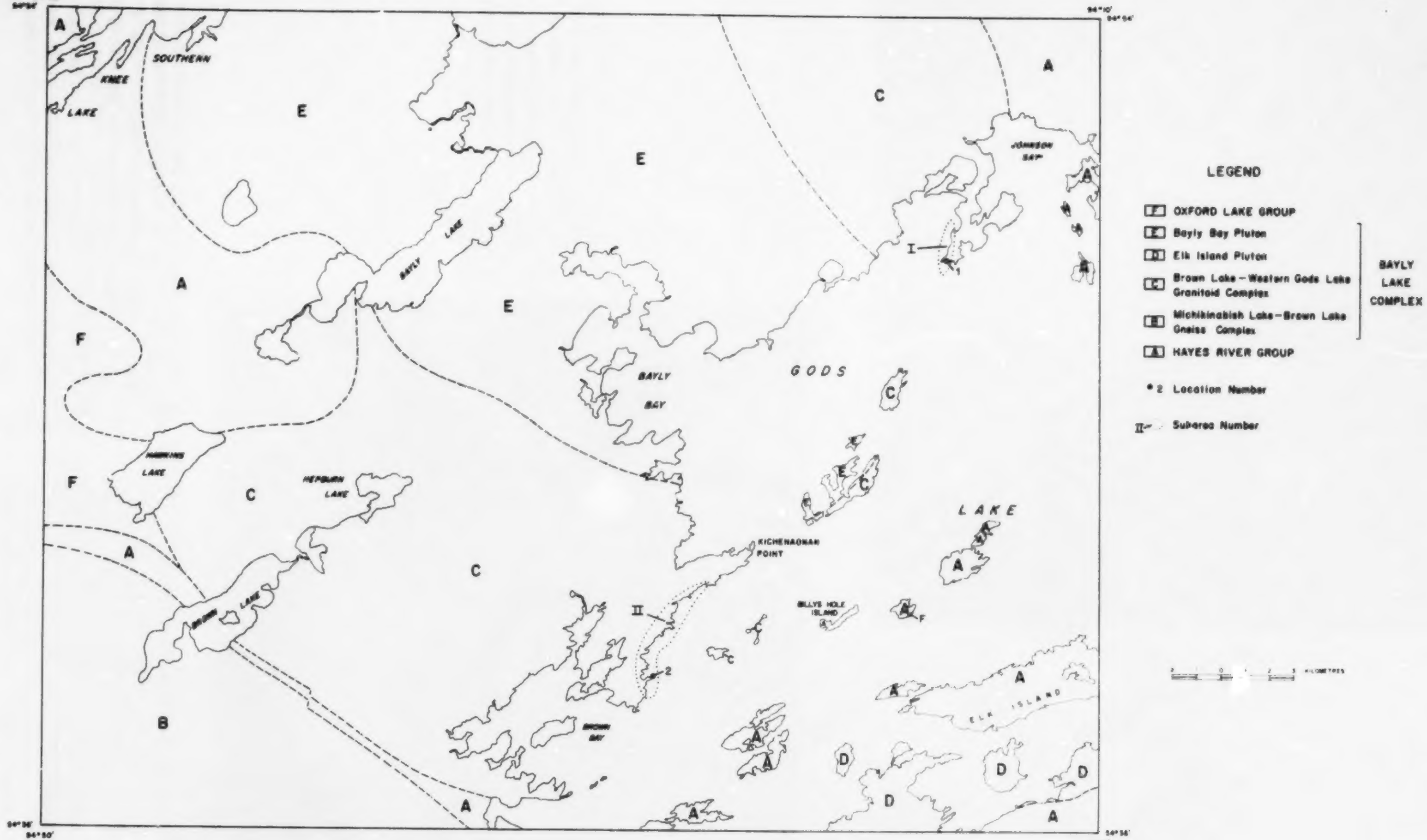

SOUTHERN
KNEE
LAKE
BAYLY LAKE
BAYLY BAY
GODS
LAKE
JOHNSON BAY
HAWKINS LAKE
HEPBURN LAKE
BROWN LAKE
BROWN BAY
KICHENAONAN POINT
BILLYS HOLE ISLAND
ELK ISLAND
A
B
C
D
E
F
I
II
1
2
LEGEND
F OXFORD LAKE GROUP
E Bayly Bay Pluton
D Elk Island Pluton
C Brown Lake – Western Gods Lake Granitoid Complex
B Michikinabish Lake – Brown Lake Gneiss Complex
BAYLY LAKE COMPLEX
A HAYES RIVER GROUP
• 2 Location Number
II Subarea Number
KILOMETRES

Figure 3: Distribution of the Hayes River and Oxford Lake Groups and the Bayly Lake Complex in the Bayly Lake-Brown Lake-western Gods Lake area.

BAYLY LAKE COMPLEX

The major part of the granitoid rocks in the Knee Lake-Gods Lake area have been interpreted as pre-Oxford Lake Group, and are assigned to the Bayly Lake Complex. The complex consists predominantly of tonalitic to granodioritic plutons and batholiths both within the greenstone belt and in extensive granitoid terranes to the north and south of the belt. Subordinate intermediate to mafic igneous rocks are also present in the complex, and an assemblage of andesitic extrusive and related sedimentary rocks (unit 5) has been mapped within the complex at Lynx Bay, western Oxford Lake (Hubregtse, 1985). The Lynx Bay assemblage is intimately associated with tonalite and felsic porphyry of unit 4, to which it is considered to be genetically related. Some migmatites of unit 6 may be derived, in part, from supracrustal rocks of Hayes River Group age or older, but otherwise the rocks of the Bayly Lake Complex postdate the Hayes River Group. The youngest intrusive phases of the complex occur in unit 7, but otherwise units 4 to 7 have not been defined on the basis of age relationships. The type area of the Bayly Lake Complex corresponds to the area of the Greenstone Project (Fig. 2). Reference localities have been defined at northeast Gods Lake, Lynx Bay, Michikinabish Lake and western Gods Lake for units 4 to 7, respectively.

METAMORPHOSED INTRUSIVE ROCKS OF MAINLY TONALITIC COMPOSITION; MINOR GRANODIORITE AND GABBRO (4)

Brown Lake-western Gods Lake granitoid complex

Gneissoid tonalite, quartz diorite, granodiorite and granite; minor pegmatite, aplite and diorite (4a)
Gneissoid tonalite (4b)
Granodioritic augen-gneiss (4e)
Hybrid rocks derived from units 1, 2 and 4 (4g)
Amphibolite (4j)

Granitoid rocks underlie a large area extending from Hawkins Lake to the western part of Gods Lake (Fig. 3) and are defined as the Brown Lake-western Gods Lake granitoid complex. The Bayly Bay pluton (7) intrudes the central part of the complex, which is predominantly tonalitic to granodioritic (Fig. 4a), with subordinate quartz diorite, quartz monzodiorite and granite (4a, b) and minor (< 5 per cent) amphibolite (4j). Three main ages of intrusion have been recognized in the complex, identified as groups A, B and C (oldest to youngest). Progressively younger phases are generally characterized by increasing microcline/plagioclase and biotite/hornblende ratios, and decreasing mafic mineral content.

Group A rocks are the most abundant, and consist mainly of tonalite, with subordinate quartz diorite and granodiorite, and minor diorite, quartz monzonite and granite. Fine- to medium-grained tonalite within group A is intruded by a later phase of medium- to coarse-grained tonalite to granodiorite of the same group. These moderately to well foliated rocks contain biotite (± hornblende) and sporadic angular mafic xenoliths and schlieren. Minor layered gneiss in group A, constituting less than one per cent of the granitoid complex, is gradational with the more massive, homogeneous rocks; the gneiss is characterized by leucocratic and mesocratic layers (0.5- 5 cm thick) of variable grain size and texture. Amphibolite occurs as concordant thin *lits* (with rare discordant branches) and thicker units (0.5-1 m thick, up to 15 m) within the layered gneiss, which is locally deformed in tight to isoclinal folds. Minor granodioritic augen-gneiss (4e) in Group A contains euhedral plagioclase (up to 1 cm) and quartz aggregates.

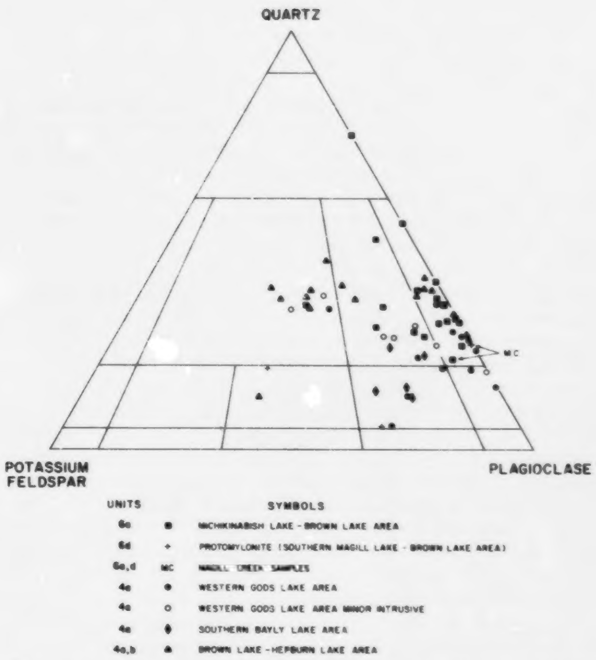


Figure 4a: *Potassium feldspar-quartz-plagioclase modal analyses of gneissoid rocks of units 4a, 4b, 6a and 6d in the Michikinabish Lake-Brown Lake-western Gods Lake area. Compositional fields are shown in Fig. 4b.*

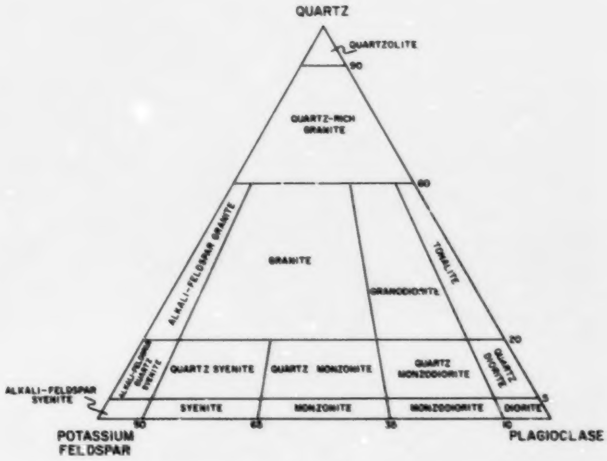


Figure 4b: *Classification of granitoid rocks after Streckeisen (1967).*

Two tonalitic to granitic phases (group B) consist of concordant boudined *lits* intruded by discordant dykes; group B rocks are massive to well foliated, and both phases intrude group A. Three pegmatitic to aplitic phases, defined as group C, occur as dykes and irregular masses constituting approximately 5 per cent of the granitoid complex. Late quartzofeldspathic veins, locally with carbonate, hornblende, pyrite or rare garnet are widespread and later microcline veinlets occupy post-tectonic fractures. The southern margin of the granitoid complex is locally strongly sheared and silicified at Brown Lake.

Compositional and lithologic units are distributed as follows:

1. A zone of granodioritic to granitic rocks at least 500 m wide and 3 km long occurs along the southern margin of the complex in the area east of Brown Lake (Fig. 3). These rocks are interpreted as part of group B, but their age is uncertain.
2. Quartz monzodiorite and granodiorite dykes intrude amphibolite (1h) at the margin of the complex at southern Bayly Lake. The dykes are well foliated, subporphyritic to equigranular, and are probably part of group B, but their age is uncertain.
3. A minor phase of monzodiorite to quartz monzodiorite (group A) occurs in the complex at Johnson Bay, Gods Lake.
4. Layered and massive granitoid gneisses (group A) occur at Johnson Bay and Kichenaonan Point, Gods Lake.

Amphibolite xenoliths (4j) and concordant amphibolite units (up to 15 m thick) are present within the granitoid rocks and layered gneisses. Xenoliths are generally lensoid, aligned parallel to the regional foliation, and partly granitized; porphyroblastic aggregates of hornblende occur sporadically and plagioclase phenocrysts locally indicate a magmatic origin. Crenulated foliations in several xenoliths indicate the amphibolites were deformed prior to their incorporation in the granite. Amphibolite interlayers are moderately to well foliated and locally display gneissic lamination (quartzofeldspathic/epidotic/hornblendic).

Amphibolite (4j) constitutes 25-75 per cent of the marginal parts of the granitoid complex southwest of Johnson Bay and southwest of Kichenaonan Point (subareas I and II, respectively, Fig. 3). The amphibolite is interpreted as derived from volcanic rocks of the Hayes River Group in the marginal, contact zone of the granitoid complex (4g). Possible pillow structures in the amphibolite at location 1 (Fig. 3) southwest of Johnson Bay support this interpretation. Amphibolites elsewhere within layered granitoid gneiss include possible para-amphibolite layers (gradational with more leucocratic gneisses) and later intrusive units (locally discordant to the gneissic layering).

Megaphyric gabbro intrudes layered granitoid gneiss (unit 4a, group A) at location 2 southwest of Kichenaonan Point (Fig. 3). The gabbro contains up to 70 per cent plagioclase phenocrysts (up to 3 cm), and displays a 10 cm wide chilled aphyric margin, which is truncated by later tonalite-granodiorite of group B. The gabbro has been mapped as unit $1e_2$ because equivalent megaphyric gabbro has only been recognized in the Hayes River Group in the Greenstone Project area. The emplacement of this gabbro within gneiss of group A therefore suggests the latter rocks at locality 2 may be older than the Hayes River Group synvolcanic gabbros.

Granitoid rocks of group A contain antiperthitic plagioclase ranging from albite (in monzodiorite) to calcic andesine (in granodiorite); the predominant composition is An_{25-35}. Microcline is replaced by later myrmekitic plagioclase. Sporadic clinopyroxene occurs in quartz diorite of group B at northwestern Gods Lake, and garnet occurs locally in granite of group C.

Northeastern Gods Lake-northern Knee Lake granitoid complex

Gneissoid tonalite, quartz diorite, granodiorite and granite; minor pegmatite, aplite and diorite (4a)

Gneissoid tonalite (4b)

Porphyritic tonalite and minor porphyritic granodiorite (4c)

Granodioritic augen gneiss (4e)

Hybrid rocks derived from units 1, 2 and 4 (4g)

The extensive granitoid terrane extending west from northeastern Gods Lake to northern Knee Lake is well exposed at the shore of Gods Lake, but outcrop inland to the northwest is sporadic due to extensive glacial drift. Massive to gneissoid tonalite to granodiorite (4a, b) is predominant in the complex (Fig. 5). Three main ages of intrusion are recognized — early gneissoid tonalite, quartz diorite and minor diorite (group I) is intruded by tonalite, granodiorite and minor granite (group II); massive to gneissoid granitic pegmatite and aplite (group III) occur as minor dykes at the south margin of the complex and larger bodies (> 50 m across) in the area to the north. Minor felsic porphyries, mafic dykes and intrusive breccia occur at the southern flank of the granitoid complex. Some diabase dykes (4h) are foliated and partly disrupted, whereas later mafic dykes (post-group III pegmatite) are massive and undeformed. Post-tectonic quartzofeldspathic veins are widespread. The three groups of granitoid rocks are well developed at Gods Lake, but further north only one of the older groups (I or II) is present, in conjunction with group III. Groups I, II and III are probably equivalent to groups A, B, and C (respectively) in the Brown Lake-western Gods Lake granitoid complex.

The south margin of the granitoid complex (4g) is characterized by skialiths and large (> 10 m) xenoliths of the basaltic host rock in various stages of granitization and assimilation. This area is comparable to the "basic border zone" of magmatic complexes described by Mehnert (1968), where early granitoid phases of variable basicity, resulting from assimilation of the host rocks, are intruded by later rocks of the interior of the complex. The basaltic rocks at northeastern Gods Lake were deformed and foliated prior to granitoid intrusion, because some related mafic xenoliths display folded foliations predating incorporation in the granitoid rock (Plate 28). Furthermore, the trend of gneissic layering in amphibolite (1h) at the west end of Yellowback Island is truncated by foliated tonalite at the contact between units 1h and 4b (Yellowback Island area, NTS 53K/13).

Group I includes gneissoid tonalite to quartz diorite (containing biotite and/or hornblende) and diorite in minor discordant zones and larger bodies (> 50 m across) within the tonalite. The diorite locally contains plagioclase phenocrysts and rare garnet; this phase is partly a result of reaction between tonalite and basaltic enclaves which are locally gradational with the diorite; elsewhere contacts with basalt are abrupt with no evidence of assimilation by the tonalite. Some early tonalite dykes (group I) are disrupted and intruded by undeformed dykes of later tonalite (group II) which truncate the foliation of the early dykes. Group II consists predominantly of medium- to coarse-grained, massive to gneissoid tonalite and granodiorite; some dykes are characterized by relatively coarser grained or pegmatitic zones in the core or at the margins of the intrusion. Subhedral quartz phenocrysts or irregular aggregates are locally prominent (unit 4c); minor granodioritic gneiss (4e) with plagioclase augen (0.5-2 cm) occurs sporadically just north of Gods Lake. Granitic pegmatite and aplite of group III is generally massive but locally strongly foliated; microcline up to 5 cm and irregular quartz aggregates and stringers occur in the pegmatite.

Alkali metasomatism is locally associated with the granitoid intrusions at northeastern Gods Lake. Pillow basalt ($1b_2$) in contact with tonalite (4b) contains irregular zones of plagioclase porphyroblasts (Plate 16) east of Hurley Island (Yellowback Island area, NTS 53K/13). Microcline stringers and porphyroblasts are locally developed at granodiorite-basalt contacts in the same area; carbonatization and alteration of the basalt to mafic schist and strong shearing are locally associated with the potassium metasomatism in zones (up to 10 m wide) parallel to the regional foliation. Minor metasomatized zones within the granitoid rocks are characterized by increased ratios of K:Na and total alkalis:SiO_2 as shown by the alteration of granite to quartz monzonite (samples A and B, respectively, Fig. 5) at Houle Island (McIvor Lake area, NTS 53L/16).

Diorite and quartz diorite consist of green hornblende, oligoclase-andesine, and minor quartz (± biotite). Zoned plagioclase phenocrysts occur locally; chloritic alteration is common, and secondary prehnite occurs locally within biotite. Carbonate, epidote, microcline, opaque minerals, sphene and apatite are accessory.

Tonalitic to granitic rocks contain biotite (± subordinate green hornblende), plagioclase and quartz which occurs as subhedral phenocrysts and later intersertal aggregates. Plagioclase is antiperthitic and commonly zoned; late myrmekitic albite is developed at the rims of perthitic microcline poikiloblasts containing quartz and plagioclase inclusions. Prominent epidote grains locally contain irregular radial fractures and cores of allanite. Minor accessories include muscovite, zircon, and sphene, which locally occurs as large euhedral crystals. Pegmatitic granite (group III) consists of albite-oligoclase, dark brown biotite, muscovite, quartz, microcline and allanite; some intrusions contain secondary stilpnomelane and tremolite.

Intrusive breccia (4d)

Polymictic intrusive breccias occur within mafic volcanic flows (1b) just east of Hurley Island (Yellowback Island area, NTS 53K/13) and on several islands in western Gods Lake, 3 km east of Kichenaonan Point (Gods Lake area, NTS 53L/9). The breccia bodies, which extend laterally for 100 m or more, occur close to or at the contacts between Hayes River Group rocks (1, 2 and 3) and granitoid complexes (4). Similar breccia occurs as thin (up to 1 m) layers within mafic rocks (1g, 1h) south of Yellowback Island. The rock is classified as intrusive breccia (Reynolds, 1954).

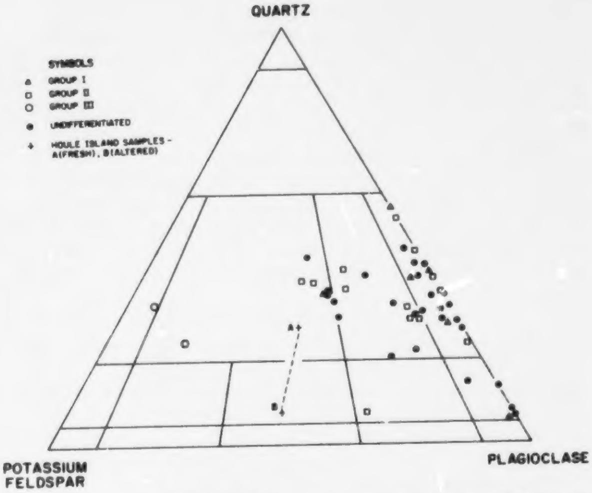


Figure 5: *Potassium feldspar-quartz-plagioclase modal analyses of rocks in the northeastern Gods Lake-northern Knee Lake gneissoid complex (4a, b, c). Compositional fields are shown in Fig. 4b.*

Plate 28: *Amphibolite xenoliths derived from basalt (1b) at northeastern Gods Lake were metamorphosed and foliated before intrusion of the tonalite (4b).*

The breccias consist of heterogeneous assemblages of clasts (up to 5 m long) derived from their host rocks (Table 5). The breccia matrix (10-30 per cent of the rock) is generally fine grained tonalite or quartz-plagioclase porphyry; porphyritic granodiorite, diabase and lamprophyre also occur locally as matrix in the breccia at the locality east of Kichenaonan Point. The clasts are very closely packed; most are angular, but a few granitoid types are well rounded (Plate 29). "Flow-trails" of clasts parallel to the elongation of the breccia bodies occur east of Hurley Island, where the breccia margins display flame-shaped apophyses intruding the mafic volcanic host rock. The breccia there is intruded by tonalite (4b) and diabase (4h), and the breccia east of Kichenaonan Point is intruded by lamprophyre (4i). Strata-bound breccia within amphibolite (1g, 1h) is truncated by late porphyry dykes (4f) south of Yellowback Island.

The diversity of clast types in the breccias indicates extensive fracturing occurred through several stratigraphic members during emplacement of the breccia and late minor intrusions (4f, 4h, 4i) associated with the granitoid plutonism of unit 4. Locally steep attitudes of "flow-trails" of the clasts indicate a vertical component of movement; horizontal movement is also indicated in the breccia east of Kichenaonan Point, where the foliation trend of the mafic host rock is deflected from north to northeast, parallel to the breccia body.

The intrusive breccias at Gods Lake resemble Precambrian intrusive breccias elsewhere reported by Reinhardt (1972), Taylor and Baer (1973), Bennett (1975) and others. The breccias are also very similar to intrusions described by Pitcher and Berger (1972) in the Donegal area, which are closely related to lamprophyres associated with granitoid plutonism. The origin of intrusive breccia is generally attributed to explosive failure of shallow rocks under the pressure of rising volatiles, followed by fluidization and incorporation of host rock fragments. The breccia at Gods Lake was apparently related to magmatic influxes, and collapse of the brecciated host rocks down the fractured zones, since the relatively dense, angular mafic clasts show no evidence of the attrition which would accompany upward transport by fluidization.

Diabase, gabbro (4h)
Lamprophyre (4i)
Lamprophyre, diabase (7h)

Mafic dykes occur sporadically throughout the granitoid complexes (4) and plutons (7) in the Knee Lake and Gods Lake areas; the dykes are most abundant at the margins of the granitoid complexes. At northeastern Gods Lake, the foliation of the earliest granitoid rocks (unit 4a, group I) is truncated by mafic dykes (4h), which in turn are locally cut by the late granitic phase (unit 4a, group III) as shown in Table 6. Diabase or lamprophyre (4h, 4i) locally constitutes the matrix of intrusive breccia (4d), which is itself intruded by later mafic dykes (4h). The diabase phases are compositionally and texturally similar; the early dyke suite is relatively more abundant than the later phase.

The mafic dykes (4h, 4i, 7h), which are generally 0.1-1 m thick, include folded and disrupted intrusions and massive, undeformed dykes. The foliation of deformed intrusions is commonly intensified towards the dyke margins, and locally slightly discordant to the latter. Irregular quartzofeldspathic schlieren and networks are developed in some intrusions; plagioclase phenocrysts and/or hornblende pseudomorphs occur in some dykes.

Several major lamprophyre intrusions (up to 40 m thick) occur within intrusive breccia 3 km east of Kichenaonan Point (Gods Lake area, NTS 53L/9). The rocks are characterized by biotite phenocrysts (up to 3 cm); well rounded xenoliths (up to 25 cm) of porphyritic granodiorite (7b) are abundant in some dykes.

Massive, mafic quartz syenite occurs at the north end of Brown Lake. The approximate composition of the rock is: hornblende and

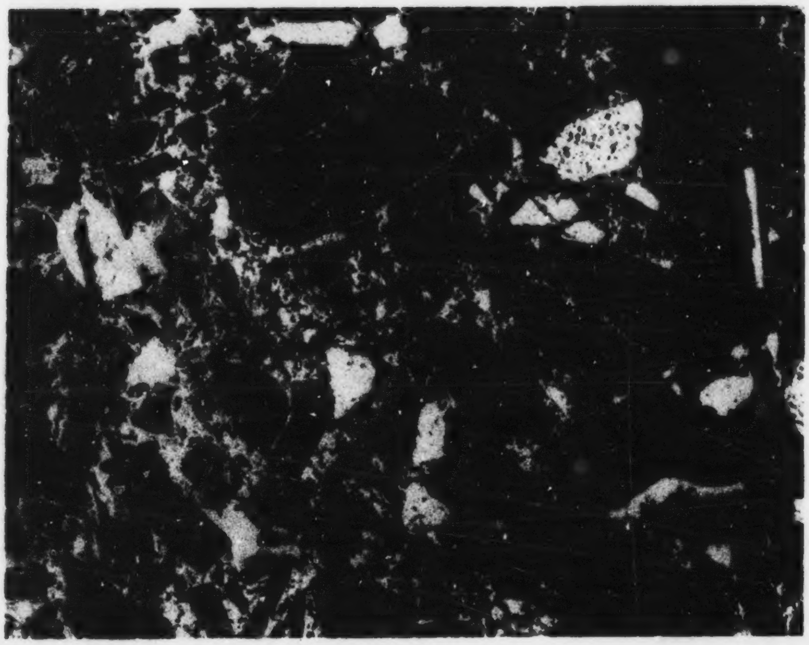


Plate 29: *Intrusive breccia (4d) at northeastern Gods Lake containing basalt, gabbro, and tonalite clasts in a massive tonalite matrix. Brecciation postdates foliation of the clasts.*

Table 5: Clast types of intrusive breccia (4d)

CLAST TYPE	DERIVATION	NOTES	FREQUENCY AND DISTRIBUTION
BASALT, PILLOWED BASALT PORPHYRITIC BASALT	1b, 1c	Massive to gneissoid. Some clasts gneissic with felsic and epidotic stringers	Predominant at both Hurley Island and at locality east of Kichenaonan Point
GABBRO, PORPHYRITIC GABBRO	$1e_1$, $1e_2$		
TONALITE	4a, 4b, 7a, 7b	Massive to gneissoid; fine- to coarse-grained; with biotite and subordinate hornblende	
GRANODIORITE, GRANITE	4a, 7b, 7c, 7d		Sporadic occurrences
PORPHYRITIC TONALITE	4c	Massive; fine- to medium-grained; with quartz and/or plagioclase phenocrysts	Occur only at locality east of Kichenaonan Point
QUARTZ DIORITE	4a	Gneissoid; medium grained; with hornblende	
LAYERED GNEISS	4a	With tonalitic and hornblendic *lits*	
PORPHYRITIC GRANITE	7c	Massive to gneissoid; medium grained; with quartz and microcline phenocrysts	
APLITE	4a, 7i		
QUARTZ-FELDSPAR PORPHYRY, FELDSPAR PORPHYRY	4f, 7g	Massive to gneissoid	
QUARTZ FELDSPAR, PYRITE		Pebbles up to 6 cm Grains up to 5 mm	

microcline (35 per cent); augite (10 per cent); quartz (4 per cent); and plagioclase (4 per cent). The quartz syenite comprises an outcrop (10 m across) within an area of tonalite-granodiorite (4a), but contacts are not exposed; the rock is tentatively assigned to unit 4h.

The mafic dykes contain essential green hornblende and andesine; accessories include clinopyroxene (pale green or less commonly brown), biotite, quartz, microcline, opaque minerals, apatite, sphene, allanite and zircon. Lamprophyres contain prominent, dark brown biotite phenocrysts with bleached cores, locally arranged in subparallel (flow?) trails. Some lamprophyres contain clinopyroxene with oscillatory zoning and lamellae of orthopyroxene. Hornblende is commonly twinned and partly recrystallized or altered to micaceous aggregates. Late alteration products include chlorite, epidote, sericite, actinolite, and carbonate.

GNEISSES AND GNEISSOID ROCKS OF MAINLY TONALITIC COMPOSITION; MINOR GABBRO, HORNBLENDITE, CLINOPYROXENITE AND AMPHIBOLITE (6)

Michikinabish Lake-Brown Lake gneiss complex

A large area of predominantly tonalitic gneisses and granitoid rocks extends from Michikinabish Lake east to Brown Lake and the area south of Gods Lake Narrows. The northern margin of this terrane corresponds to a major topographic lineament marking the contact with the Knee Lake-Gods Lake greenstone belt to the north; southwards, the gneisses extend to the north shore of Munro Lake, where they are in contact with the Munro Lake greenstone belt to the south (Fig. 2). The Michikanabish Lake-Brown Lake gneiss complex contains migmatites derived, in part, from supracrustal rocks, and at least four intrusive granitoid phases which have undergone a protracted history of deformation and metamorphism. The supracrustal remnants may be contemporaneous and equated with the Hayes River Group, or they may be derived from relatively older strata. An isotopic K/Ar age of 2380 Ma has been obtained for gneissoid tonalite in the complex just south of Gods Lake Narrows (Burwash et al., 1962)., but the ages of the main plutonic and metamorphic events in the complex are not known. Contacts between the tonalitic gneisses and the Hayes River Group are intrusive and/or faulted. The gneiss complex (6) is interpreted as equivalent in age to the granitoid complexes (4) west and north of Gods Lake, from which it is distinguished by the presence of layered tonalitic gneisses and stromatic migmatites together with more massive granitoid phases; tonalitic gneisses comprise only a very minor part (less than 1 per cent) of the granitoid complexes (4). Subordinate amphibolite units (1 cm to several m thick) constitute 5-10 per cent of the gneiss complex; where these exceed 10 m they have been indicated (unit 6b) on the map (Munro Lake area, NTS 53L/11).

Layered tonalitic to granodioritic gneiss with concordant amphibolite layers (6a)

Layered gneisses, constituting 5-10 per cent of the complex, are characterized by 0.5-15 cm layers defined by variable composition and grain size. These rocks are intimately associated with more homogeneous granitoid units occurring as minor veins and major concordant units (1 m to over 100 m thick). Stromatic and nebulitic migmatites are locally developed by reaction between the gneissic and granitoid units.

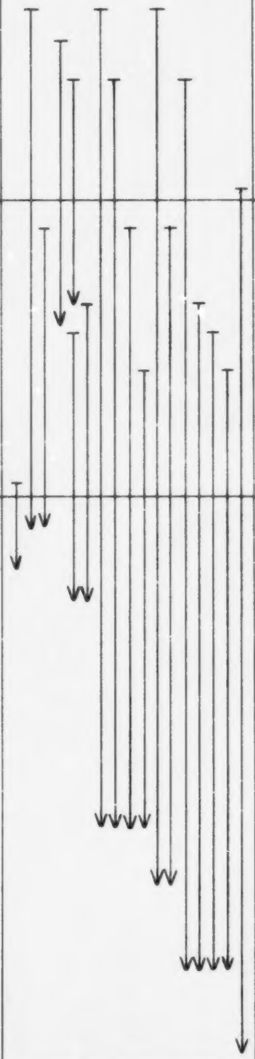
At least five intrusive granitoid phases may be distinguished (Table 7) — tonalite to quartz diorite (oldest); tonalite to granodiorite (as pegmatoid leucosomes parallel to the gneissic layering); two younger tonalitic phases (discordant to the gneissic layering); and pink pegmatite (6e). The early intrusive phases resulted in partial granitization and assimilation of supracrustal remnants and amphibolite, with local development of schlieren and feldspar porphyroblasts. Contemporaneous or subsequent attenuation parallel to the gneissic layering resulted in local boudinage and partial disruption of the gneisses and amphibolite interlayers. The gneissic layering is locally deformed in tight to isoclinal folds (D$_2$, Table 7) with moderate to steep plunges trending parallel to the regional foliation.

Protomylonitic rocks (6d) were produced locally by D$_3$ shearing and granulation of the gneisses, commonly accompanied by epidotic

Table 6: Plutonic and tectonic histories of the granitoid complex (4) at northeastern Gods Lake

1. Regional foliation of Hayes River Group rocks (predates emplacement of granitoid rocks (4).
2. Emplacement of tonalite, quartz diorite, and minor diorite (group I of units 4a, 4b).
3. Folding, dislocation, and boudinage of group I dykes.
4. Emplacement of tonalite, granodiorite, and granite (group II of units 4a, 4b and 4c).
5. Emplacement of intrusive breccia (4d) and felsic porphyry and mafic dykes (4f, 4h, 4i); some dykes are contemporaneous with group II and others are later; some also intrude the intrusive breccia.
6. Folding, dislocation and boudinage of minor intrusions (4f, 4h, 4i).
7. Emplacement of granitic pegmatite and aplite dykes (group III of unit 4a).
8. Deformation of group III dykes.
9. Intrusion of mafic dykes (4h).
10. Brittle deformation accompanied by greenschist facies metamorphism.

Table 7: Tectonic, metamorphic and plutonic histories of the Michikinabish Lake-Brown Lake gneiss complex (6).

METAMORPHIC EVENT	MINERAL	MODE OF OCCURRENCE	METAMORPHIC REACTIONS (INTERPRETED FROM MICROSCOPIC TEXTURES)	MIGMATITIC AND INTRUSIVE PHASES	STRUCTURES	DEFORMATION EVENT
M_1 (Greenschist to amphibolite facies)	Plagioclase	(a) Xenocrysts in hornblende (b) Porphyroblasts*		Layered gneiss and minor tonalitic intrusions	Development of S_1 foliation and gneissic layering	D_1
	Biotite	(a) Xenocrysts in plagioclase and hornblende (b) Corroded grains*				
	Quartz	Xenocrysts in hornblende and plagioclase				
	Epidote	Sporadic grains corroded by oligoclase*				
	Pyrite	Disseminated				
M_2 (Amphibolite facies)	Plagioclase	Poikiloblastic calcic oligoclase		Regional migmatization, granitization and metasomatism; widespread emplacement of tonalite	Similar to isoclinal folding of S_1, local boudinage and disruption of S_1 layering; development of S_2 foliation parallel to S_1	D_2
	Green Hornblende (Locally tremolite)	(a) Grains corroding biotite (Locally associated with microcline) (b) Poikiloblasts				
	Biotite	Non-corroded grains				
	Magnetite	In mafic schlieren in migmatite				
	Microcline	(a) In mafic screens in granitoid gneiss (b) Poikiloblasts (rare)			Rare occurrence of possible refolded folds indicates two fold phases may follow D_1	
M_3 (Greenschist facies)	Plagioclase	(a) Albitic rims and microveins in oligoclase (b) Myrmekitic grains adjacent to microcline		Minor mafic dykes, minor tonalitic intrusions		D_3
	Biotite	Fine grained alteration of hornblende		Minor tonalitic intrusions	Shear zones parallel to S_2 and development of S_3 cataclastic foliation (unit 6d). (Associated dynamometamorphic effects: deformation of plagioclase twin-lamellae and mica cleavages; plagioclase deformation twinning; straining; dislocation and granulation of felsic minerals	
	Quartz	Interstitial grains corroding other minerals and concordant stringers				
	Microcline	(a) As for quartz (b) Associated with alteration biotite (biotite + plagioclase $\rightarrow$ microcline + epidote)				
	Sericite	Alteration of oligoclase or biotite (locally associated with microcline)				
	Epidote	(a) Fine grained alteration of oligoclase (b) Randomly distributed grains within chlorite			Minor faults normal to S_2	
	Chlorite	Fine- to medium-grained, after biotite or hornblende (commonly associated with sphene)		Emplacement of pegmatite (unit 6e)		
	Hematite	Thin rims on pyrite			Minor fractures (filled with epidote, quartz, sericite)	

*These modes of occurrence may be of M_2 age veining. These rocks are well developed along the north margin of the gneiss complex in the vicinity of Brown Lake. Pink granitic gneisses (with microcline porphyroblasts) occur as thin *lits* (0.5-5 cm) and thicker units (up to 3 m) within the protomylonitic rocks. The contact between the tonalitic rocks (6a) and older amphibolite (1h) to the north is intrusive, and locally characterized by strong shearing and development of mylonite. Blastomylonite (1k) is developed extensively at the north margin of the gneiss complex at Gods Lake Narrows (Gods Lake and Vermilyea Lake areas, NTS 53L/9 and 10). A 30 cm cataclasite layer is exposed at Magill Creek (Plate 12) and tonalite and amphibolite are tectonically interleaved at the margin of the complex at McLaughlin Lake (Munro Lake and Oxford House areas, NTS 53L/11 and 14).

The tectonic, metamorphic and plutonic histories of the gneiss complex are summarized in Table 7. The development of gneissic layering and regional foliation were associated with greenschist or amphibolite facies metamorphism (M_1) and tonalitic intrusions. Regional migmatization and widespread tonalitic plutenism accompanied later amphibolite facies metamorphism (M_2). Localized shearing, development of protomylonite (6d), and greenschist facies metamorphism are characteristic of M_3. Minor brittle fracturing and emplacement of pegmatite (6e) are the latest events.

The massive and layered granitoid and gneissic rocks consist largely of quartz, plagioclase and biotite (± hornblende ± microcline). Plagioclase (generally calcic oligoclase) is commonly antiperthitic and locally occurs as euhedral poikiloblasts (up to 3 cm); granophyric and myrmekitic textures occur sporadically. Thin mafic screens (0.5-1 cm thick) of hornblende (± biotite) are locally developed between mesocratic and leucocratic zones in migmatites; these probably result from metasomatism, characteristic of the early stage of granitization (Reynolds, 1954). Prominent epidote grains with cores of allanite and radial microfractures occur in some intrusive phases. Microcline commonly replaces plagioclase and locally occurs as sporadic poikiloblasts. Sphene, apatite, muscovite, zircon and opaque minerals are accessory. Late minor alteration (chloritic, sericitic and epidotic), granulation and recrystallization of quartz occur sporadically throughout the gneiss complex.

Amphibolite (6b)

Massive to well layered amphibolite occurs as minor *lits* in layered gneiss (6a) and major concordant units up to 80 m thick. Fine laminae defined by variable hornblende, plagioclase and epidote contents, and rare hornblende-garnet-bearing lenses occur in the layered amphibolite, which is intruded and partly altered by gneissoid tonalite (6a). Amphibolite *lits* within layered tonalitic gneiss, which contain up to 15 per cent quartz, may be para-amphibolites, but the origin of the rocks is uncertain since no primary structures are preserved. Laminated amphibolite units are similar to some Hayes River Group rocks (units 1g, 1h) and are interpreted as enclaves of altered mafic volcanic rocks.

Amphibolite also occurs sporadically as massive or slightly foliated, minor intrusions in gneissoid tonalite. The intrusions are generally parallel to the gneissic layering and are locally boudinaged and truncated by late (D_3) shear zones.

The amphibolite consists largely of green hornblende (locally actinolite) and plagioclase (oligoclase-andesine); quartz, epidote, apatite, sphene, microcline and opaque minerals are accessory. Hornblende pseudomorphs in one unit display lamellar structure probably derived from intergrowths of original pyroxene; this feature, and sporadic occurrences of oscillatory zoning of plagioclase are indicative of a magmatic origin for the rock. One dyke contains prominent biotite blades (up to 2 cm long) partly altered to hornblende and chlorite. Subhedral serpentine pseudomorphs occur in another dyke.

Protomylonitic quartz monzonite, dioritic gneiss (6d)

Protomylonitic granitoid rocks (predominantly quartz monzonite) extend along the north margin of the tonalitic gneiss complex for approximately 15 km in the Brown Lake area. These rocks are gradational with blastomylonite (1k) in the vicinity of Gods Lake Narrows. Protomylonitic rocks also occur sporadically elsewhere within the gneiss complex.

The cataclastic rocks are laminated, with medium grained, cream, granitoid and subordinate finer grained dioritic gneiss *lits* (0.5-6 cm thick); mafic units up to 20 cm thick constitute up to 10 per cent of some outcrops. Cataclastic layering, boudinage of mafic laminae, and protomylonitic to mylonitic layers (up to 50 cm thick) are characteristic. Minor drag-folding and disruption of the layering occur sporadically; dislocated gneissic blocks are locally partly rotated between minor shears subparallel to the foliation. Two phases of cataclastic deformation have been recognized in blastomylonite (1k) at Gods Lake Narrows and microcline blastesis occurred between the two phases (Marten, pers. comm.). Microcline porphyroblasts also occur sporadically in the protomylonitic rocks, and locally are confined to narrow concordant zones.

Contacts between unit 6d and amphibolite (1h) to the north are sharp and locally tectonically interleaved with alternation of granitoid and amphibolitic units at a scale of 0.1-5 m. Protomylonitic quartz monzonite at the north margin of the gneiss complex is gradational southwards with the predominantly tonalitic rocks of the complex.

The quartz monzonite consists largely of plagioclase, microcline, quartz and brown biotite (± hornblende ± actinolite). The texture is protomylonitic (10-50 per cent crushed matrix as defined by Spry, 1969), with minor undeformed, massive zones. Antiperthitic plagioclase (albite-oligoclase) displays patchy zoning and deformation twinning, and is replaced by perthitic microcline. Microcline poikiloblasts are locally dynamically recrystallized and cross-hatched twinning is altered to a reticulate pattern. The poikiloblasts are commonly rimmed by myrmekitic plagioclase. Fibrous bundles of hornblende, aggregates of stilpnomelane, and muscovite porphyroblasts occur sporadically. Chlorite, epidote, sericite and carbonate are widespread products of alteration, probably contemporaneous with late granulation of feldspars and recrystallization of quartz in anastomosing trails.

Mafic *lits* contain green hornblende poikiloblasts and andesine-labradorite with accessory quartz, green-brown biotite and pyrite; concentrations of apatite or sphene occur locally, and some *lits* are completely altered to chlorite and epidote.

Cataclasite at the north margin of the tonalitic gneiss complex (6) at Magill Creek contains brecciated tonalite, quartz, and plagioclase fragments in a very fine grained, epidotic matrix (Plate 12). Related protomylonite at this location is texturally gradational between mylonite and tonalite.

The protomylonitic rocks are interpreted as the tectonized north margin of the Michikinabish Lake-Brown Lake gneiss complex. Mafic *lits* and boudins are probably derived from xenolithic and skialithic remnants of the amphibolite (1h) which occurs immediately north of the gneiss complex.

The composition of the protomylonitic rocks varies from quartz monzonite to tonalite (Fig. 4a); cataclastic deformation at Magill Creek is associated with a decreased potassium feldspar:plagioclase ratio, as shown by the two M.C. samples (Fig. 4a), but elsewhere protomylonitic rocks are commonly enriched in microcline. The chemical changes associated with development of cataclasite at Magill Creek include desilication, loss of K_2O and Na_2O, increase of Fe_2O_3 and CaO, and slight hydration and carbonatization (Table 8). The local concentration of apatite and sphene in mafic *lits* is probably a result of the increased mobility of P and Ti during the cataclasis; these elements are also mobilized at an early stage of granitization (Reynolds, 1954).

Pegmatite (6e)

Massive pink pegmatite occurs as minor dykes (average 1 m thick) and sporadic irregular masses (up to 60 m) constituting 5-10 per cent of the Michikinabish Lake-Brown Lake gneiss complex. The intrusions are generally parallel to the regional foliation trends (east to southeast) and are generally subvertical to vertical (locally horizontal); the pegmatite is post-tectonic and locally truncates the tonalitic gneiss layering. Some dykes contain tonalitic, aplitic marginal zones and coarser grained, granitic cores. Tourmaline prisms (up to 5 cm long) are locally concentrated in zones parallel to the dyke trends. Two phases of pegmatite intrusion are locally evident.

The pegmatite consists largely of microcline, albite-oligoclase and quartz, with accessory green-brown biotite and muscovite. Zoned, antiperthitic plagioclase is partly replaced by microcline, which is finely perthitic. Plagioclase inclusions within microcline are locally arranged in crystallomorphic patterns. Dark blue to green, euhedral tourmaline contains quartz and feldspar inclusions. Later dendritic tourmaline is associated with recrystallization of quartz, possibly contemporaneous with replacement of microcline by late myrmekitic plagioclase. Epidote contains allanite cores and radial microfractures. Occasional accessories include almandine, apatite, sphene and magnetite. Chloritic and sericitic alteration is associated with straining and deformation twinning of plagioclase.

The pegmatite is interpreted as magmatic rather than metasomatic in origin because dyke emplacement was associated with dilation. A magmatic origin for fine perthite (by low temperature exsolution) as suggested by Gates (1953) supports this interpretation. The pegmatite melt may be a product of anatexis or a late differentiate of major plutonism. The widespread occurrence of tourmaline supports the latter interpretation (Mehnert, 1968) and the lack of evidence for a genetic relationship between the pegmatite and the gneissic host rock is consistent with this mode of origin.

METAMORPHOSED INTRUSIVE ROCKS OF MAINLY GRANODIORITIC COMPOSITION; GRANITE AND TONALITE; MINOR SYENITE (7)

Tonalite (7a)

Tonalite, granodiorite and porphyritic granodiorite(7b)

Granodiorite, granite and porphyritic granite (7c)

Four plutons and associated minor intrusions consisting largely of tonalite and granodiorite are emplaced within and at the margins of the Knee Lake-Gods Lake greenstone belt. These rocks are distinguished from the majority of the granitoid phases in units 4 and 6 by their essentially massive and homogeneous texture and by the configurations of the unit 7 intrusions which are ovoid or contain marginal ovoid lobes. Pronounced foliations are developed locally at the margins of the plutons (7), but internally the bodies are massive or very slightly gneissoid. Xenoliths are common at the margins of the intrusions, but internally inclusions are rare and the plutons are generally homogeneous. Intrusions of units 4 and 6, in contrast, consist of several granitoid phases which are commonly foliated and include subordinate layered gneisses; these rocks occur in extensive granitoid terranes and contacts with the greenstone belt are generally relatively straight. The ages of emplacement of unit 7 and units 4 and 6 are probably partly overlapping, but minor intrusions of unit 7 occur within granitoid rocks of 4 and 6 at several localities (e.g. western Gods Lake); the relatively potassium-rich composition and massive texture characteristic of unit 7 suggest these rocks represent the youngest part of the Bayly Lake Complex.

Table 8: Chemical analyses of tonalite (6a) and derived cataclasite (6d) at Magill Creek.

	Tonalite (6a) wt. per cent	Cataclasite (6d) wt. per cent
SiO_2	67.65	56.2
Al_2O_3	18.10	18.5
Fe_2O_3	0.77	6.12
FeO	1.13	0.76
CaO	4.00	13.51
MgO	0.90	0.54
Na_2O	5.45	2.05
K_2O	1.48	NIL
TiO_2	0.32	0.71
P_2O_5	0.08	0.13
MnO	0.03	0.12
H_2O	0.40	1.34
CO_2	0.10	0.20

ELK ISLAND PLUTON

The Elk Island pluton forms the western part of a batholith extending from the area north of Gods Lake Narrows eastwards for approximately 100 km to Stull Lake, Ontario (Fig. 2). The pluton consists of a main tonalite-granodiorite phase (IV) and subsidiary minor intrusions of tonalite to granite constituting less than 10 per cent of the pluton (Table 9). Phases I, II, IV, VI and VII are widespread but III and V are more restricted; phases I to VII are progressively younger, but mutual age relationships between VA, VB and VC are not known.

The main phase (IV) is a white to pink, medium- to coarse-grained rock with ovoid to subhedral quartz phenocrysts (0.4-1 cm) and poikilitic microcline megacrysts (1-5 cm). There is a complete gradation from rocks with euhedral microcline to rock types with irregular microcline aggregates (Plate 30). The massive to slightly foliated rock has hypidiomorphic to xenomorphic-granular texture. Grain size decreases from the interior towards the west end of the pluton where the rock is porphyritic (subarea A, Fig. 6). Related quartz-feldspar porphyries (7g) up to several hundred metres thick intrude mafic volcanic rocks (1) west of the pluton, north of Gods Lake Narrows. Tonalite (Phase IV) at the south shore of Elk Island is associated with magnetiferous quartz diorite and diorite, probably resulting from the assimilation of mafic volcanic rocks at the margin of the pluton.

Mafic schlieren occur both parallel and discordant to pluton margins; some schlieren have been folded during intrusion. The Elk Island pluton displays a weak foliation defined by biotite and quartz which dips steeply (70°-90°) and trends west to west-northwest except at the margins of the pluton, where the foliation is parallel to the contacts. The foliation locally truncates earlier schlieren and north-trending trails of microcline megacrysts in the interior of the pluton, which are attributed to flow during emplacement. Synplutonic granitoid dykes within the pluton display foliations parallel to their margins, and are commonly discordant to the weak foliation of the pluton, which is deflected by the dykes.

Mafic xenoliths, probably derived from volcanic rocks of unit 1, are massive to strongly foliated or gneissic, similar to laminated amphibolite (1g); the gneissosity predates incorporation of these bodies in the pluton. The xenoliths are angular to ovoid, and variously assimilated by the tonalite-granodiorite; alteration of the xenoliths is associated locally with plagioclase blastesis and development of magnetite and sphene aggregates in the mafic rock. Minor remobilization after emplacement of the pluton is indicated by the local resorption of synplutonic dykes, cross-cutting mafic schlieren, and the occurrence of rare foliated cognate inclusions rotated out of the plane of the granitoid foliation.

Emplacement of the Elk Island pluton was accompanied by deformation of the host rocks, which become increasingly attenuated toward the pluton margins. Early dykes extending out from the main intrusion are locally folded and dislocated by later stresses probably associated with the plutonism. Contacts with the Hayes River Group rocks are sharp, locally agmatitic and/or strongly sheared. Amphibolite within 5 m of the pluton margin is locally hornfelsed with development of porphyroblasts of green hornblende and rare clinopyroxene or anthophyllite.

Regional compositional variations within the pluton include gradation from tonalite to granodiorite eastwards from the west end of the pluton in subarea A and northwards in subarea B (Figs. 6 and 7); subarea C is largely tonalitic. Quartz phenocrysts and microcline megacrysts are widespread in the western and northern parts of the pluton, but quartz phenocrysts occur only sporadically in the tonalitic southern part, which locally contains prominent plagioclase phenocrysts close to the south margin.

Positive aeromagnetic anomalies in subarea C, Fig. 6 (taken from Map 3360G, Federal-Provincial Aeromagnetic Series) probably represent supracrustal rocks close to the south margin of the pluton. The elongate anomaly (3 x 20 km) within the pluton corresponds to a zone containing enclaves of amphibolite interpreted as part of a roof pendant.

Plate 30: *Microcline megacrysts in granodiorite (7b) containing oriented inclusions of plagioclase (white) and quartz (dark). Large euhedral megacrysts are gradational to smaller, irregular microclines; incipient quartz phenocrysts occur in the upper part of the stained slab. From Elk Island pluton, Gods Lake.*

Table 9: Phases of granitoid rocks of the Elk Island pluton

Phase	Composition	Texture		Phenocrysts	Mode of Occurrence	Notes
I (Oldest)	Quartz diorite	Porphyritic	Slightly foliated to well foliated	Plagioclase	Dykes in basalt	Medium grey intermediate matrix
II	Tonalite	Porphyritic		Plagioclase ± quartz	Xenoliths in pluton and dykes in basalt	Pale grey to cream felsic matrix
III	Tonalite	Subporphyritic		Plagioclase	Relictic zone in pluton	
IV	Tonalite to granodiorite	Porphyritic; matrix is hypidiomorphic to xenomorphic-granular)	Massive to slightly foliated	± Quartz (abundant) ± Microcline (common)	Main phase of pluton (comprises > 90 per cent of intrusion)	Medium- to coarse-grained
VA	Granodiorite	Porphyritic		Plagioclase + quartz	Dykes in pluton	Pale to medium grey matrix; intruded by remobilized granodiorite host rock
VB	Granodiorite	Same as IV		± Microcline	Dykes in pluton	Fine- to medium-grained
VC	Hornblende granodiorite	Same as IV		± Quartz ± Microcline	Dykes in porphyritic granodiorite stock (7b) 10 km north of Gods Lake Narrows	Contaminated by abundant basalt and gabbro xenoliths
VI	Granodiorite to granite	Pegmatitic and aplitic			Dykes in pluton and basalt; most abundant at margins of pluton	Two phases of dykes. Commonly zoned — e.g. pegmatite core, aplite margin or quartz core, granophyric margin. Associated with potassium metasomatism and quartz veins and masses; locally contain garnet
VII	Quartz				Veins and irregular masses in pluton and in basalt	Stilpnomelane, axinite, feldspar and/or epidote occur in some veins

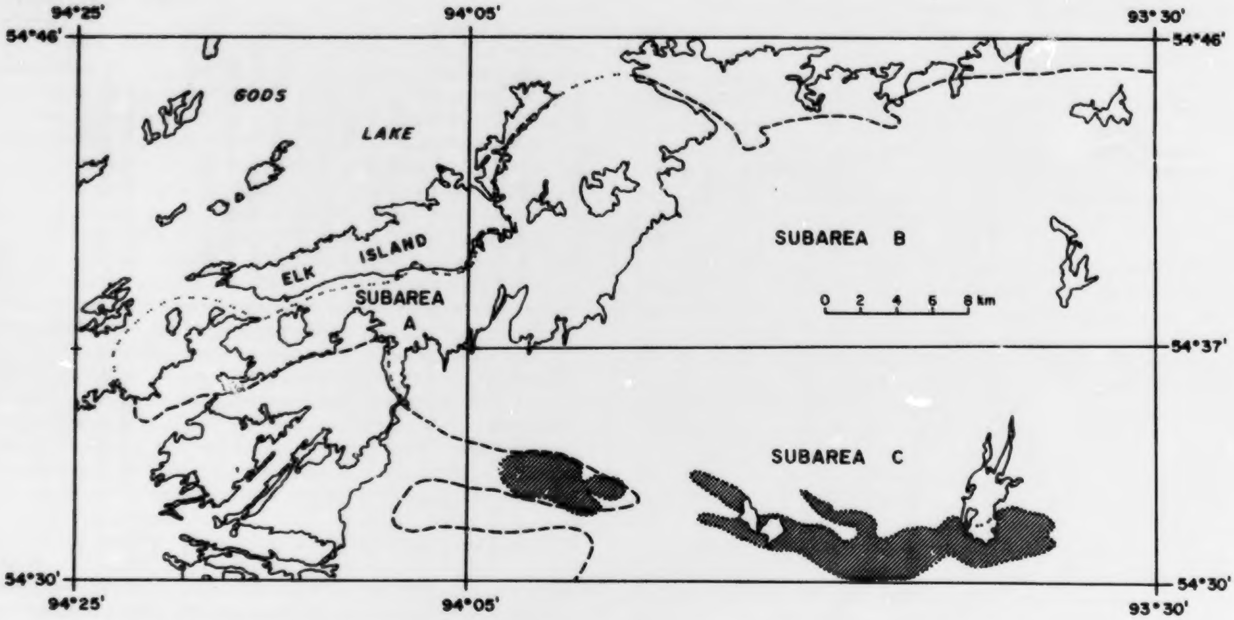


Figure 6: Subareas of the Elk Island pluton; the shaded areas define positive aeromagnetic anomalies in subarea C.

BAYLY BAY PLUTON

The Bayly Bay pluton extends from western Gods Lake through Bayly Lake to southern Knee Lake (Fig. 3). The ellipsoidal northwest-trending pluton corresponds to a prominent aeromagnetic low (Map 7294G, Oxford House, Federal-Provincial Aeromagnetic Series). The intrusion consists largely of a single, mainly granodioritic phase similar to the main phase of the Elk Island pluton, but the compositional range is relatively more restricted (Fig. 8). Minor intrusive phases constitute less than 5 per cent of the Bayly Bay pluton; these include fine grained porphyritic granodiorite (with plagioclase and quartz phenocrysts), granite, tonalite, pegmatite and aplite, and rare mesocratic hornblende granodiorite.

Dykes related to the Bayly Bay pluton locally intrude gneissoid tonalite (4b) at Gods Lake. Sporadic mafic schlieren and xenolith trails within the intrusion are generally conformable with the pluton margins but locally discordant. A very weak biotite-quartz foliation is concordant with the outline of the intrusion. The margins of the pluton are generally parallel to the foliation trends of the mafic volcanic host rocks (1) at southern Knee Lake, but the foliation of the volcanics is locally truncated by the granodiorite, indicating a post-metamorphic age of intrusion. Contacts are locally highly sheared; epidote-rich mylonite occurs at the pluton margin 6 km northeast of Kichenaonan Point, Gods Lake.

GODS RIVER PLUTON

The Gods River pluton (7) is a lobate intrusion at the west end of the extensive granitoid terrane (4) at northeastern Gods Lake. The pluton consists of tonalite at the west which is gradational to granodiorite and granite to the north and east (Fig. 8); this pattern is similar to the

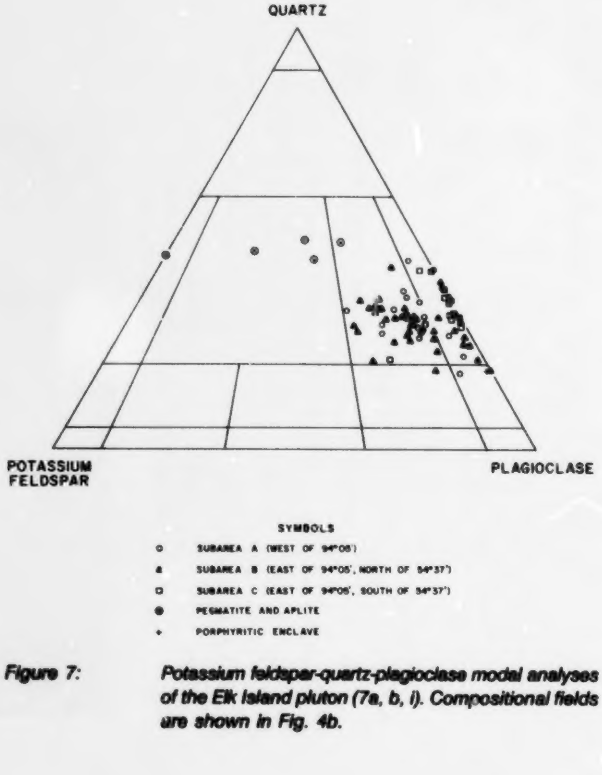


Figure 7: Potassium feldspar-quartz-plagioclase modal analyses of the Elk Island pluton (7a, b, i). Compositional fields are shown in Fig. 4b.

regional variation in composition in the Elk Island pluton (Figs. 6 and 7). Quartz phenocrysts are widespread, and the rocks are similar to the main phase of the Elk Island pluton, except for the absence of microcline megacrysts at Gods River. Localized contact metamorphism (hornblende blastesis) is evident in amphibolitic host rocks at the margin of the Gods River pluton. Sporadic dykes of granitic pegmatite and aplite, alaskite and plagioclase-phyric tonalite occur within the pluton; porphyritic tonalite also occurs as rare xenoliths. Quartz-plagioclase porphyry dykes (7g) are abundant in the area immediately west of the pluton. A pegmatite dyke (7l) over 2 km long, containing spodumene and beryl, occurs close to the northeast shore of Johnson Bay (Southard, 1977). Contact relations between units 4 and 7 at Houle Island indicate the Gods River pluton postdates gneissoid tonalite of group I (unit 4a) but is contemporaneous with granitoid rocks of group II (4a).

SELLER LAKE PLUTON

The Seller Lake pluton underlies a large part of Seller Lake and extensive glacial drift covers much of the intrusion (Knee Lake and Parker Lake areas, NTS 53L/15 and 53M/2, respectively). The pluton is granodioritic to granitic (Fig. 8) and lithologically very similar to the Elk Island pluton, consisting of relatively homogeneous, massive granitoid rocks with an incipient foliation (defined by quartz and biotite) trending west-northwest. Quartz phenocrysts (up to 1 cm) and microcline megacrysts (up to 3 x 6 cm) each constitute 10-30 per cent of the rock; minor zones (1-2 square metres) contain up to 75 per cent microcline. Rare trails of microcline and mafic xenoliths are parallel to the incipient foliation. Minor intrusions of pink pegmatite and/or aplite occur sporadically in the pluton. Contacts with the Hayes River Group host rocks are sharp with little or no evidence of alteration by the granitoid rocks.

Biotite is generally predominant over green hornblende in the granodiorite-granite (7b, c), but minor contaminated phases contain hornblende to the exclusion of biotite. Ovoid to subhedral quartz phenocrysts are gradational with intersertal quartz, which postdates subhedral zoned plagioclase (mainly oligoclase, locally albite). Plagioclase commonly contains quartz inclusions and antiperthitic patches; rare oscillatory zoning occurs in marginal parts of the plutons. Perthitic, poikilitic microcline megacrysts with plagioclase inclusions in crystallomorphic patterns are commonly rimmed by myrmekite (Plates 30 and 31). Albitized rims are characteristic of the inclusions and the myrmekitic plagioclase. An early phase of microcline occurs as inclusions within plagioclase xenocrysts in the microcline megacrysts. Corrosion textures locally indicate brown to green biotite predates plagioclase but is later than epidote. Muscovite porphyroblasts are locally developed within plagioclase. Minor accessories include red-brown sphene, magnetite, apatite, zircon, allanite, pyrite and rare tourmaline. Late alteration products include biotite, chlorite, carbonate, sericite, and saussurite.

Quartz-feldspar porphyry, feldspar porphyry (4f)
Quartz-feldspar porphyry (7g)

Quartz-feldspar porphyries are tonalitic to granodioritic (Fig. 9) and are most abundant in marginal parts of the granitoid complexes (4) and in host rocks close to the complexes and plutons of unit 7; quartz-plagioclase porphyry also occurs as xenoliths and rare dykes within the plutons. There are no distinctive differences between porphyries of units 4f and 7g. At least three phases of porphyry are associated with the Elk Island pluton — quartz dioritic, mesocratic porphyry (Phase I, Table 9) is intruded by leucocratic tonalitic porphyry (Phase II) in the area northeast of Gods Lake Narrows; both phases are truncated by porphyritic tonalite-granodiorite of the main plutonic phase (IV). Rare granodioritic porphyry dykes (V) occur within the main phase of the Elk Island pluton; similar mesocratic porphyries which cut the tonalitic porphyry (II) northeast of Gods Lake Narrows may be equivalent to phase VA.

The porphyries are cream to grey or blue-grey and contain ubiquitous plagioclase phenocrysts (15-40 per cent of the rock, up to 60 per cent) and quartz phenocrysts (0-15 per cent, up to 25 per cent of the rock). Hornblende porphyroblasts are common. The matrix is fine- to very fine-grained, with biotite (± hornblende) constituting 5-10 per cent of leucocratic porphyries, and 10-25 per cent of mesocratic types. The dykes are moderately foliated, locally strongly sheared, especially at the margins. Mafic xenoliths are more common in mesocratic than leucocratic dykes. The porphyry dykes are generally parallel to the

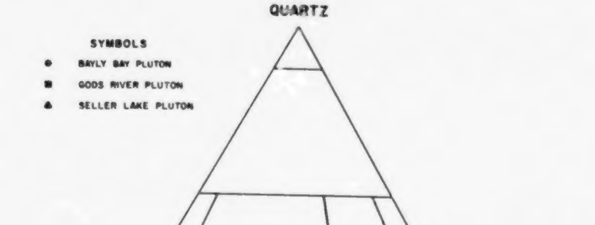


Figure 8: Potassium feldspar-quartz-plagioclase modal analyses of the Bayly Bay, Gods River and Seller Lake plutons (7a, b, c). Compositional fields are shown in Fig. 4b.

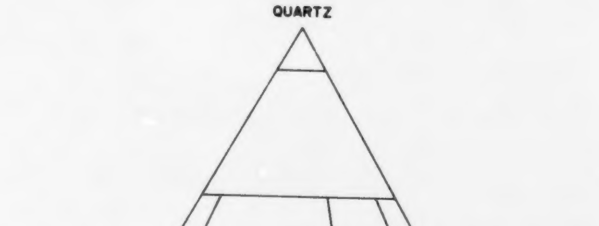


Figure 9: Potassium feldspar-quartz-plagioclase normative analyses of quartz-feldspar porphyries (7g). Compositional fields are shown in Fig. 4b.

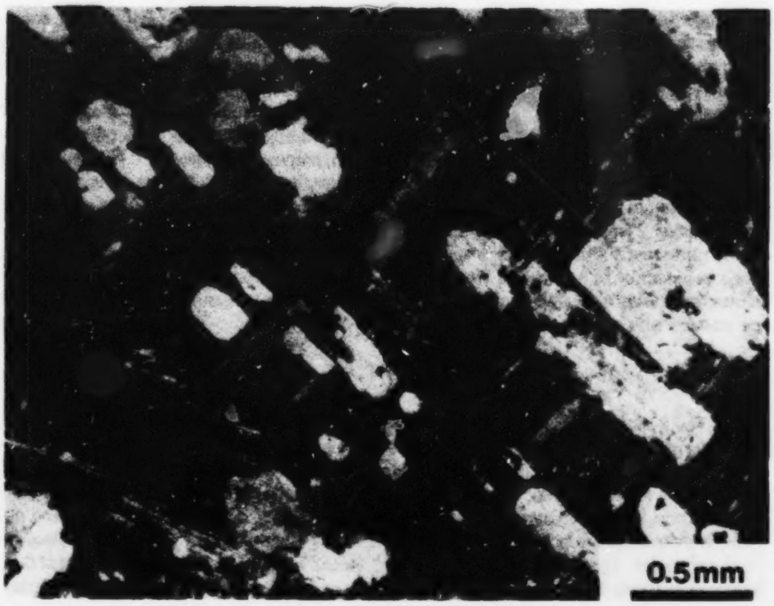


Plate 31: *Oriented plagioclase inclusions (albite) in part of a microcline megacryst in granodiorite (7b); plagioclase grains at microcline rims are also albitic. A late microfracture cuts the megacrysts (upper part of photomicrograph). From Bayly Bay pluton, southern Knee Lake. (Crossed nicols).*

regional foliation trend of mafic volcanic host rocks; some dykes are tightly folded, disrupted, or boudinaged.

Euhedral to ovoid albite-andesine phenocrysts (2-8 mm) display complex twinning and normal to oscillatory zoning. Some phenocrysts contain antiperthitic patches, muscovite porphyroblasts, or secondary aggregates of chlorite. Quartz phenocrysts (0.2-1 cm) are generally strongly corroded and embayed. Biotite is partly chloritized; porphyroblasts or aggregates of green hornblende (or less commonly actinolite) are locally replaced by micaceous, epidotic aggregates. Plagioclase and hornblende crystals are generally randomly oriented, but locally subparallel. Mafic aggregates and recrystallized quartz phenocrysts are commonly deflected around more competent plagioclase crystals. Carbonate constitutes up to 25 per cent of some dykes and locally occurs as a replacement of plagioclase or in quartzofeldspathic aggregates in the strain-shadows of phenocrysts. Accessory minerals include sphene, magnetite, pyrite, and rare allanite, zircon and tourmaline. Traces of molybdenite, malachite and sphalerite occur in some leucocratic porphyries.

The majority of the porphyry dykes are spatially and temporally closely associated with the major granitoid intrusions (4, 7) and a genetic relationship is inferred. However, the age of some dykes is uncertain because synvolcanic porphyries (3a) are lithologically similar to those of units 4f and 7g.

MODE OF EMPLACEMENT OF GRANITOID COMPLEXES (4, 6) AND PLUTONS (7)

The differences between the granitoid and gneiss complexes (4, 6) and the plutons (7) are attributed to the tectonic stages and crustal levels at which the rocks were emplaced. The complexes were intruded with contemporaneous deformation (Tables 6 and 7); migmatites are widespread in unit 6, and minor layered gneisses occur in the Brown Lake-western Gods Lake granitoid complex (4). The regional foliations and margins of the complexes are largely conformable with the trends of the greenstone belt. These features are consistent with synkinematic emplacement (Marmo, 1968) in contrast to the granitoid plutons (7) which are not accompanied by significant deformation and are locally discordant to the regional structural trends of the greenstone belt. A late- to post-kinematic stage of emplacement is interpreted for the plutons (7). Their ovoid, diapiric forms and relatively homogeneous character are also consistent with a shallower crustal level than that represented by the granitoid and gneiss complexes (4, 6).

Southern Knee Lake-Magill Lake Area

METAMORPHOSED PORPHYRITIC VOLCANIC ROCKS AND RELATED SEDIMENTARY ROCKS (8)

A volcanic complex of breccias, flows and related intrusive and sedimentary rocks extends for at least 23 km from the west end of southern Knee Lake eastwards to the south shore of the lake; the estimated maximum thickness of the section is 800 m. The complex is similar to the volcanic subgroup of the Oxford Lake Group (8) at eastern Oxford Lake (Hubregtse, 1985). Individual fragmental and extrusive volcanic units are mostly too narrow to be identified on the maps (GR83-1-6 and -7) and have been grouped together in unit 8e. Pillowed shoshonite and porphyritic andesite ($8b_2$, $8c_2$) and mafic tuff (8h) occur as distinctive marker units extending for up to 8 km along strike (Knee Lake area, NTS 53L/15). Twenty-three major element analyses of the volcanic rocks of unit 8 and related diabase are given in Appendix B.

Massive and pillowed shoshonite ($8b_2$)
Massive and pillowed porphyritic andesite ($8c_1$, $8c_2$)

Porphyritic intermediate volcanic units (up to 180 m thick) occur at the west end of the volcanic complex and close to the north and south margins in the central and eastern parts of the complex. The flows are compositionally similar to high potassium andesite and shoshonite in the Jackson Bay area, Oxford Lake (Hubregtse, 1978).

Intermediate flows are medium grey to medium green, whereas more felsic extrusives weather pale grey to green. Pillowed flows are gradational laterally with massive flows and possible sills; most flows are non-pillowed. Dark grey, very fine grained micaceous material occurs at pillow margins and as irregular masses between pillows. Radially disposed carbonate amygdales (up to 3 cm long) are developed peripherally in the pillows, which are generally 1 x 2 m (up to 1 x 12 m). Flow structures are locally developed including streaky layering (defined by variable plagioclase content) and fine dark laminae, which outline rare primary folds indicating the direction of flow (Plate 32). Flow brecciation occurs sporadically; one flow displays a flow-front and basal zone with mixed volcanic fragments incorporated from the substrate (location 1, Fig. 10).

Several synvolcanic dykes at the east end of the complex are compositionally similar to the intermediate flows and some clasts in related breccia (8e). One latite dyke can be traced into a probably extrusive unit, and a discordant dacitic intrusion (60 m thick) is emplaced in pyroclastic rocks (8e) which contain fragments identical to the dacite (location 2, Fig. 10).

Plagioclase laths (0.5-1 cm) constitute 10-40 per cent (up to 75 per cent) of the rocks; the phenocrysts are antiperthitic and commonly crowded with very fine inclusions of quartz. The laths are generally randomly oriented; subparallel flow orientation is rare. Subordinate quartz phenocrysts (less than 10 per cent of the rocks) are ovoid or, rarely, subhedral. Microcline phenocrysts are uncommon. Twinned green hornblende pseudomorphs (after pyroxene) are commonly turbid with opaque minerals (Plate 33). Very fine grained aggregates of biotite (or chlorite) and magnetite are probably pseudomorphic. Shoshonites contain up to 25 per cent biotite in the matrix, and carbonate and hornblende are locally abundant. Accessory minerals include muscovite, epidote, magnetite, pyrite and sphene, and rare apatite and zircon.

Plate 32: *Flow lines in porphyritic andesite (8c), indicating movement from left to right (base of flow towards base of photograph); location 1, Fig. 10.*

Volcanic fragmental rocks and conglomerate with porphyritic, felsic to intermediate and minor mafic fragments, minor tuff and wacke (8e)

Polymictic pyroclastic breccia, tuff-breccia, and crystal- and lapilli-tuff (8e) are best developed in the central and eastern parts of the volcanic complex which contains the most proximal facies of fragmental rocks. Pyroclastic breccia is composed predominantly of mafic to felsic volcanic fragments, with subordinate tuffaceous, sedimentary and hypabyssal types (Table 10). Two to four clast types are generally present; a visual estimate at 55 locations indicated predominance of dacitic to andesitic clasts at 41, rhyolitic types at 12, and basaltic fragments at 2 locations. Clast size ranges up to 3 m across; the size of the largest fragments varies inversely with the matrix percentage of the breccia (Figs. 11 and 12). Primary clast shapes, which are well preserved in the eastern part of the complex, are generally subangular, ranging from angular to subrounded (Plate 34); central and western parts of the complex are characterized by moderate to strong deformation (Plate 35) —

Plate 33: *Porphyritic andesite (8c) with hornblende pseudomorphs (after pyroxene) and corroded phenocrysts of plagioclase and quartz — from southern Knee Lake. (Crossed nicols).*

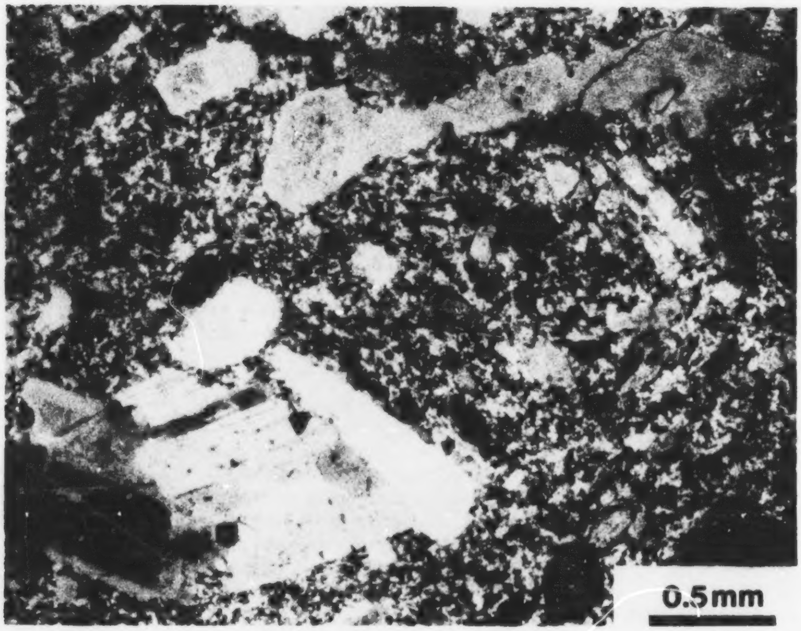


Plate 34: *Tuff breccia (8e) with unsorted, angular clasts of volcanic and volcaniclastic rocks in a crystal-tuff matrix; located north of location 2, Fig. 10.*

Table 10: Clast types in volcanic fragmental rocks (8e) at southern Knee Lake

SAMPLE NUMBER	SiO_2 (wt. per cent)	CLAST TYPE	PHENOCRYSTS		HORNBLENDE PORPHYROBLASTS	BIOTITE PSEUDOMORPHS AFTER HORNBLENDE	MATRIX	NOTES	COLOUR OF WEATHERED SURFACE
			QUARTZ	PLAGIOCLASE					
32-3-5016-2	72.55	RHYOLITE		+	+	+	medium grained, trachytic texture	subporphyritic, with sporadic tourmaline	cream to pale grey
32-2-1537-1	71.05	RHYOLITE	+	+		+	fine grained		cream
32-3-5105-1	68.1	DACITE	+	+	+	+	fine grained	trachytic texture	medium grey
32-2-1487-2	64.75	DACITE	+	+	+	+	very fine grained		medium grey
32-1-326-3	60.75	ANDESITE		+	+	+			medium grey
32-3-5205-1	60.10	ANDESITE		+	+	+			pale blue-grey
32-3-5246-1	55.6	ANDESITE		+	+	+			pale grey
32-2-1515-1	54.15	ANDESITE			+	+			dark green-grey
32-3-5319-3	53.15	BASALT		+			fine- to medium-grained	contains 8 per cent pyrrhotite	medium to dark green
32-1-355-2	50.25	BASALT		relictic plagioclase				altered to amphibolitic schist	medium green

ACCESSORY FRAGMENTS

CLAST TYPE	PROVENANCE
TUFF; LAPILLI-TUFF; TOURMALINE-BEARING PYROCLASTIC ROCKS	8e
MAFIC TUFF	8h
LAMINATED SILTSTONE; CHERT	8g
GABBRO; PORPHYRITIC DIABASE	8i
EPIDOTIZED VOLCANIC ROCKS	
QUARTZ	

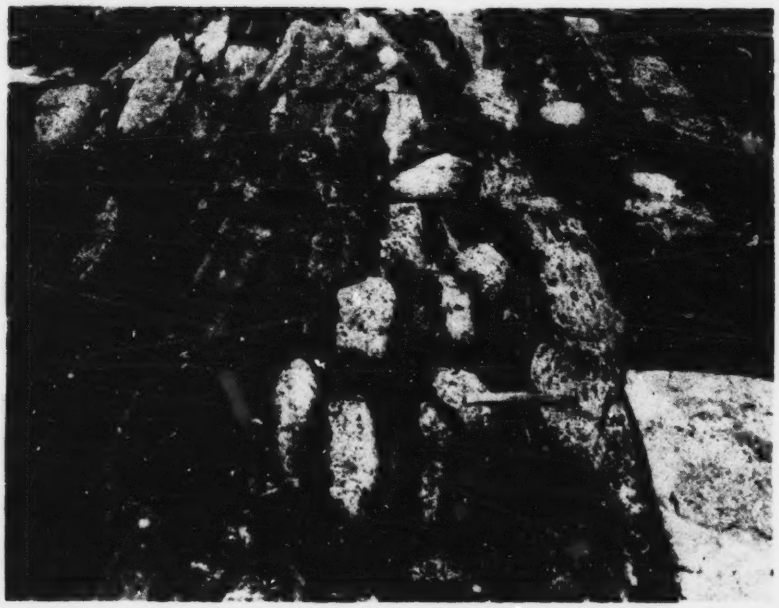


Plate 35: *Interlayered tuff and pyroclastic breccia (8e) with moderately flattened clasts (from near location 6, Fig. 10).*

clasts are ovoid to highly flattened with subhorizontal attenuation and elongation ratios up to 16:1 (Fig. 13). Concentric zoning occurs in some clasts (e.g. relatively pale weathering rims and/or epidote-rich cores). The micaceous tuff or crystal-tuff matrix is generally intermediate (locally mafic) and constitutes 10-20 per cent of the coarsest pyroclastic breccia (Plate 36 and Fig. 11).

Tuffaceous interlayers within the breccia, which are similar to the breccia matrix, contain detrital plagioclase (± microcline ± quartz) in a micaceous groundmass (Plate 37). Lapilli-tuff is generally poorly layered but locally graded, and cross-bedding and scoured surfaces were observed at a few places. Tuffaceous units associated with relatively coarse breccia are typically lensoid (1-5 m thick) and contacts between tuff and breccia commonly gradational. Layering is progressively better developed towards the western (more distal) part of the volcanic complex, where bed thickness ranges from 2 cm-1 m (Plate 38).

Subhedral to subangular plagioclase phenocrysts are widespread and predominant over quartz; detrital microcline occurs sporadically. A poorly developed lamination (defined by variable biotite content) occurs in some tuffs; foliation is generally prominent. Carbonate is common, locally poikiloblastic, and euhedral green hornblende (partly altered to biotite) constitutes up to 10 per cent of the tuffs. Minor accessories include magnetite, muscovite and rare tourmaline. Alteration products (sericite, epidote) and carbonate are more abundant in the more strongly deformed rocks in the central and western parts of the volcanic complex than in the east.

Feldspathic greywacke, siltstone, argillite and minor chert (8g)

Fine grained sedimentary rocks within the volcanic complex occur as subordinate interlayers generally less than 10 m thick; larger units (up to 100 m) are locally developed. Chert beds (up to 50 cm thick) are rare. Sedimentary rocks (8g) are best developed in the eastern part of the volcanic complex, where they overlie coarse pyroclastic breccia in the core of a syncline (location 1, Fig. 10). The sediments at that locality are predominantly pale- to medium-grey or beige feldspathic greywacke with subordinate darker siltstone or cream siliceous units interlayered at a scale of 5-50 cm. The rocks display grading, cross-bedding, scour channels, flame structures, and primary folds with amplitudes of up to 80 cm (Plates 39 and 40). Irregular folding of some laminae (Plate 41) is attributed to drag associated with dense, sediment-laden turbidity flows; gravity sliding and loading of soft sediment may also have produced some deformation. The greywacke contains subordinate pebble beds (up to 5 cm thick) and minor zones of pebbly greywacke within or at the base of individual beds. The pebbles (and subordinate cobbles) are angular to subrounded; clast types include felsic to intermediate volcanic rocks, laminated siliceous siltstone, porphyritic diabase and hornblendite. Siltstone and chert rip-ups occur in some beds (Plates 39, 40 and 41); sporadic volcanic boulders are interpreted as bombs. Some beds contain fine epidotic laminae; strata-bound, ovoid epidotic bodies (1-4 cm across) occur at the peninsula west of location 1 (Fig. 10).

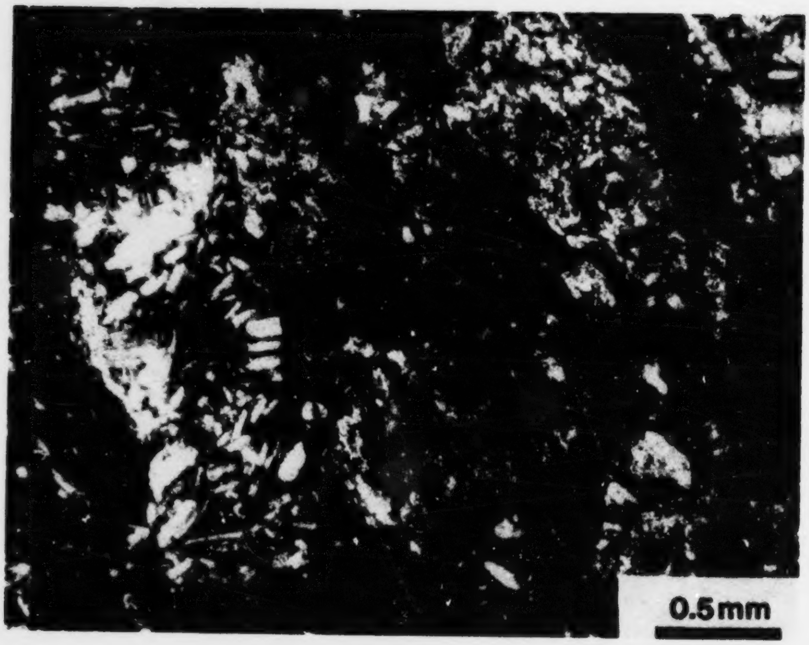
The greywacke contains detrital grains of subhedral to subangular plagioclase, subordinate quartz and rare microcline, and sporadic volcanic granules in a very fine grained, micaceous siltstone matrix. Pyrite, apatite, sphene, zircon and tourmaline are accessory. Secondary chlorite and carbonate are widespread.

Tuff and lapilli-tuff (8h)

Conspicuous interlayers of bright green mafic tuff and lapilli-tuff (rich in actinolite + biotite ± chlorite) are best developed in the central and eastern parts of the volcanic complex. The composition of mafic tuff (see Appendix B) ranges from potassium-rich basalt to absarokite (equivalent to basalt with greater than 2 per cent K_2O — Mackenzie and Chappell, 1972). Mafic tuff units are 1-7 m thick (up to 30 m) and well layered (0.5-10 cm beds) or massive; grading and cross-bedding are locally developed. Hornblende and chlorite porphyroblasts, prominent tourmaline prisms (up to 3 cm) and pyrite and chalcopyrite occur in some units (Plate 42). Lapilli include basalt, hornblendite, and reworked fragments of tuff. The mafic tuffs are moderately to strongly foliated and locally display strain-slip cleavage.

Contacts between the tuffs and interlayered flows and breccias are generally sharp, but some mafic tuff units are gradational with

Plate 36: Matrix of pyroclastic breccia (8e), comprised of very fine grained epidote and minor carbonate and biotite with comminuted fragments of quartz, plagioclase, and volcanic rocks — from southern Knee Lake. (Crossed nicols).



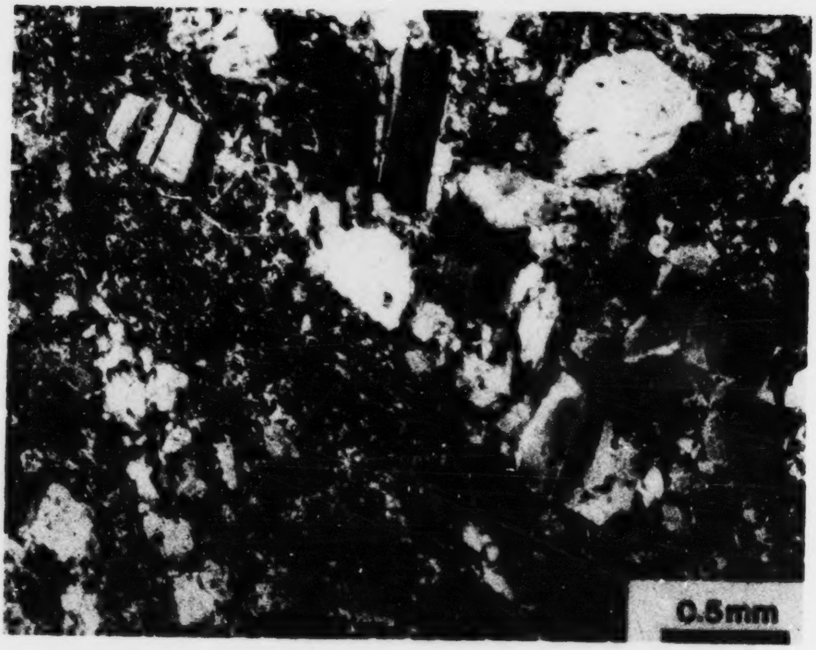


Plate 37: Crystal tuff (8e), consisting of subhedral to angular feldspar and volanic fragments in a quartz-feldspar-biotite matrix with minor epidote and carbonate — from southern Knee Lake. (Crossed nicols).

Plate 38: *Well layered, graded tuffs (8e) — tops are towards the top of the photograph. Located 1 km northwest of location 6, Fig. 10.*

pyroclastic breccia (8e). Finely laminated mafic tuff lenses (up to 0.15 x 1.5 m) are locally intercalated with coarse pyroclastic breccia (location 3, Fig. 10). Some tuff beds are interlayered with feldspathic greywacke (10a) in a transitional zone between the volcanic complex (8) and the metasedimentary section (9 and 10) to the south, indicating a conformable sequence in that area (south of Long Island, Fig. 10).

The mafic tuff consists largely of actinolite and yellow-brown biotite; amphibole generally constitutes 40-50 per cent of the rock (up to 95 per cent). Porphyroblasts of hornblende, biotite and chlorite occur locally; the hornblende blasts are partly recrystallized or altered to biotite, and chloritization of biotite is widespread. Subordinate plagioclase is very fine grained or occurs as larger detrital grains. Carbonate is common, locally constituting up to 50 per cent of the tuff. Minor accessories include epidote, apatite, sphene, muscovite and magnetite.

Porphyritic diabase, gabbro (8i)

Mafic sills and dykes, which are most abundant in the eastern part of the volcanic complex, are generally 0.5-3 m thick (up to 15 m). The intrusions are considered to be synvolcanic because of their spatial relationship with the volcanic rocks of unit 8 and the lithologic similarity of some dykes to porphyritic basalt clasts in pyroclastic breccia (8e) (compare Plates 43 and 44). Similar diabase occurs as a sill within the Oxford Lake Group sedimentary section (9, 10) south of Michikanes Lake, extending laterally for at least 6.5 km, and up to 450 m thick (Oxford House area, NTS 53L/14). The porphyritic diabase is massive to well foliated and characterized by green to brown-green weathered surfaces, commonly pitted due to the preferential weathering of hornblende pseudomorphs. Textures are gradational from porphyritic to equigranular in the thicker gabbroic intrusions.

Porphyritic diabase at southern Knee Lake contains euhedral, zoned andesine phenocrysts and green hornblende pseudomorphs (after pyroxene) in an intermediate to mafic, hornblendic matrix with up to 15 per cent biotite. Some dykes in the eastern part of the volcanic complex are aphyric. Hornblende is partly recrystallized or altered to biotite. Subordinate quartz constitutes up to 15 per cent of the rock. Some dykes contain ovoid biotite-magnetite aggregates (up to 1 cm) which are

Plate 39: *Fine grained, graded sediments (8g) display flame structures, rip-ups, and parallel lamination — close to location 1, Fig. 10.*

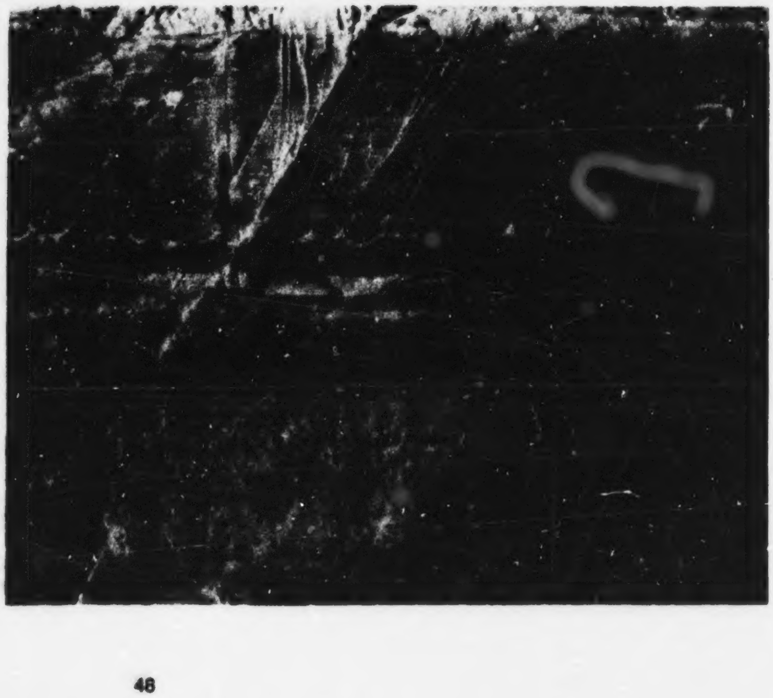
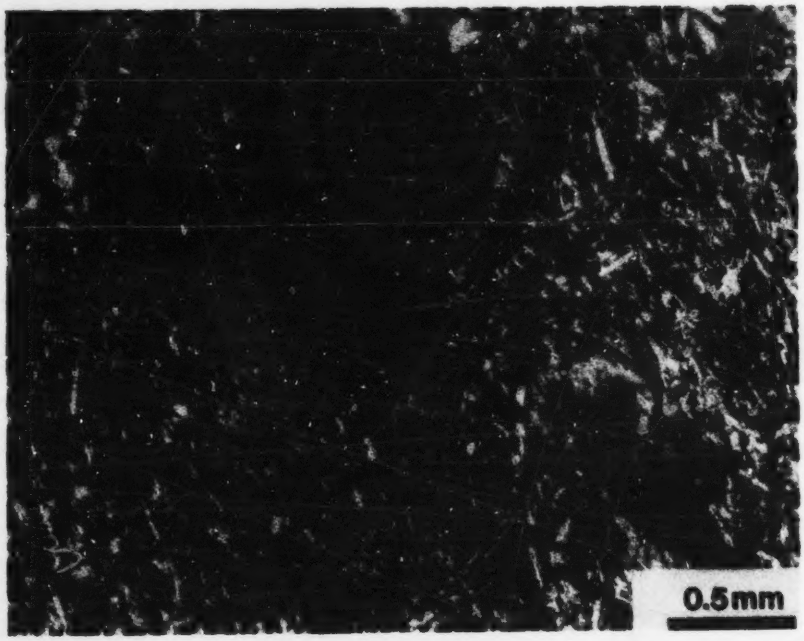


Plate 40: Folded and disrupted layering in feldspathic greywacke-siltstone sequence (8g) — close to location 1, Fig. 10; an irregular fragment of well laminated greywacke has been reworked into the coarser grained bed above.

Plate 41: Folding, disruption, and reworking of fine grained sediments (8g) during deposition of relatively coarser grained, graded beds above — near location 1, Fig. 10.

Plate 42: Mafic tuff (8h) at southern Knee Lake; anhedral chlorite and euhedral tourmaline porphyroblasts are randomly distributed in an actinolite-biotite-chlorite matrix. (Crossed nicols).



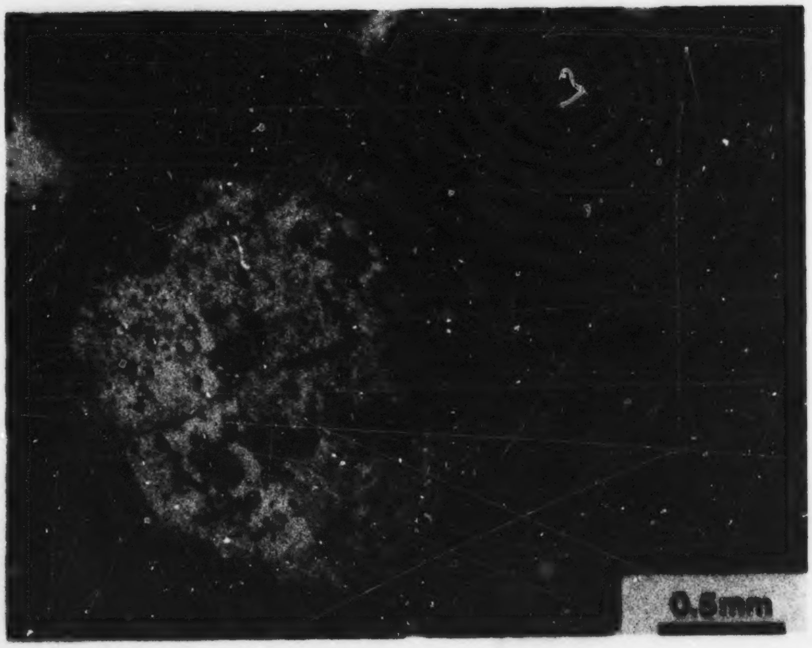


Plate 43: Porphyritic diabase sill (8i) at southern Knee Lake containing pseudomorphs of hornblende (after pyroxene) in a fine grained biotite-epidote-feldspar matrix. (Crossed nicols).

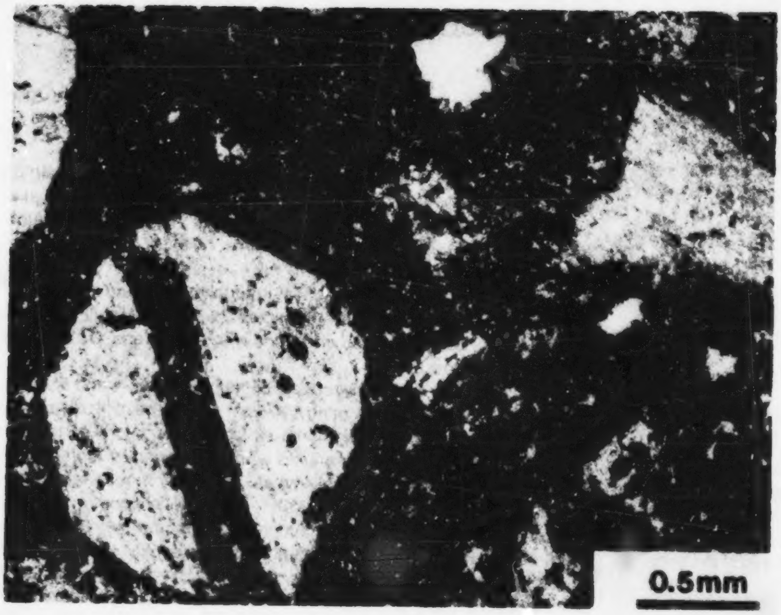


Plate 44: *Porphyritic basalt clast in pyroclastic breccia (8e) at southern Knee Lake; hornblende pseudomorphs (after pyroxene) are partly altered to biotite in a fine grained biotite-epidote matrix. (Crossed nicols).*

possibly pseudomorphic. Carbonate is a common accessory, locally abundant in altered chloritic or epidotic zones. Minor accessories include pyrite, apatite, sphene and muscovite.

The metamorphic grade of porphyritic diabase in the body south of Michikanes Lake is higher than at southern Knee Lake. The amphibole is coarser grained, and plagioclase is more calcic (up to An_{68}); biotite is red-brown and hornblende medium green, whereas at southern Knee Lake biotite is yellow-brown, and amphibole pale green. Alteration is more limited and carbonate relatively less abundant in the diabase south of Michikanes Lake.

Depositional environment of the volcanic complex (8)

The volcanic complex is interpreted as part of a largely subaqueous volcanic edifice; this may have included subaerial deposits which were partly or wholly reworked into an adjacent sedimentary basin. The polymictic nature of pyroclastic breccias (8e) is consistent with reworking, although the angularity of the fragments in many breccias and generally poor sorting indicate any reworking was of limited extent. Well laminated, graded mafic tuffs (8h) are similar to formations in the Lamotte region of Quebec interpreted as turbidity current deposits (Gélinas et al., 1975). The structures of fine grained sedimentary rocks (8g) at southern Knee Lake indicate rapid accumulation by turbidity flows with contemporaneous slumping and incorporation of intraformational debris; intercalated pyroclastic deposits may have been emplaced by turbidity flow or possibly by air-fall into the sedimentary basin. The occurrence of pillowed flows (8b2, 8c2) also indicates a subaqueous environment for at least a part of the volcanic complex.

Regional variations in pyroclastic textures within the volcanic complex

Pyroclastic deposits are characterized by systematic variation of textures relative to distance from volcanic centres (Fisher, 1964; Smith et al., 1973; Fox, 1976). A survey was conducted at southern Knee Lake to investigate the variation and distribution of clast size and shape, matrix percentage and degree of sorting of pyroclastic rocks in the volcanic complex (8). These parameters were recorded at 100 locations within the complex. A factor representing the approximate size of the largest fragments at each location was derived by multiplication of the elliptical axes of the section of the clasts on approximately horizontal outcrop surfaces. The matrix percentage was recorded at each station by a systematic count of either clast or matrix (at least 200 points at 10 cm spacing) using a 1 m square grid. The predominant fragment shape at each location was classified as angular, subangular, subrounded or rounded (according to Williams et al., 1958); deformed clasts in attenuated breccias were classified as ellipsoidal. The degree of sorting was rated as fair, poor, or absent. The results of the survey may be summarized as follows:

1. Locations of maximum clast size and lowest matrix percentage are generally coincident. The coarsest breccias occur in the eastern part of the complex, and in the central part due south of Long Island (Figs. 11 and 12). The occurrence of several maxima of clast size in both the eastern and central localities may be a result of structural repetition. The eastern locality is also characterized by the greatest local variation of clast shape and degree of sorting, and fragments are generally more angular and more poorly sorted than elsewhere in the volcanic complex (Fig. 13).
2. The coarsest breccias in the eastern locality occur in the axial zones of anticlines (Figs. 10 and 12).
3. Clasts are generally well flattened in central and western parts of the complex (Fig. 13).

The accuracy of the investigation is limited by the variable extent of strain within the complex, and by the procedures employed for determining clast size and shape which can only provide approximate results. However, the accuracy of the data is considered to be sufficient for the identification of the trends described. The results of the survey of pyroclastic textures are consistent with those of similar investigations cited previously. Breccias closest to their volcanic source generally contain the largest and most angular fragments, are poorly sorted or unsorted, and display greater local variations of these features than rocks more distant from the centre of volcanism. The two localities characterized by the coarsest breccias at southern Knee Lake are probably close to volcanic sources, but the locations of the centres of volcanism are not necessarily intersected by the present erosion surface. The largest fragments measured, which occur at locations 4 and 5 (Fig. 10), are 3.2 x 1.6 m and 1 x 0.85 m, respectively; bombs of similar size have been found up to 5 km from their vents in recent volcanic eruptions (Minakami, 1942; Thorarinsson, 1954). Identification of the eastern part of the complex as proximal to a volcanic centre is consistent with the distribution of minor felsic to mafic synvolcanic intrusions, which are most abundant in that area (Fig. 10).

Structure and stratigraphic relationships of the volcanic complex (8)

Several major folds have been mapped within the volcanic complex in the area southeast of Long Island (Fig. 10). The lateral extent of the folds is at least several kilometres but their full extent is uncertain. Limited structural data in the central and western parts of the complex indicates a south-facing section with subvertical to overturned primary layering. Detailed stratigraphic analysis close to the south and north margins of the complex (locations 6 and 7, Fig. 10) indicates possible stratigraphic equivalence of these locations (Table 11), consistent with the pattern of repeated folding identified in the area southeast of Long Island.

The north margin of the volcanic complex (8) is in fault contact with rocks of the Hayes River Group; several occurrences of unit 3f in the western part of the complex are interpreted as fault-bounded inliers of the Hayes River Group. The south margin of the volcanic complex is in conformable contact with younger feldspathic greywacke (10a) to the south; the latter unit is interlayered with mafic tuff (8h) in a 600 m wide transitional zone between units 8 and 10 (Fig. 10).

METACONGLOMERATE; MINOR METAGREYWACKE (9)

Polygenic conglomerate, minor pebbly greywacke and greywacke (9b)

A conglomerate body (approximately 2 km wide) containing granitoid, volcanic and sedimentary clasts occurs east of Magill Lake, between mafic volcanic flows (1b, 1c) to the east and feldspathic greywacke (10a) to the west (Knee Lake area, NTS 53L/15). Similar conglomerate, approximately 250 m thick occurs within feldspathic greywacke (10a) in the area east of McLaughlin Lake, and as minor intercalations within greywacke in the southern parts of Magill Lake and Hawkins Lake (Oxford House and Vermilyea Lake areas, NTS 53L/14 and 53L/10, respectively).

The conglomerate (9b) consists of pebbles, cobbles and sporadic boulders (up to 75 cm) constituting 50-75 per cent of the rock; clast types are listed in Table 12. The fragments, which are very poorly sorted, are subangular to subrounded; granitoid types are generally more rounded and less deformed than other types. Relatively thin conglomerate formations (e.g. at southern Magill Lake — Plate 45) are commonly more strongly attenuated than larger bodies of conglomerate. Oligomictic chert-cobble conglomerate is present within the polymictic deposits as rare lenses, and occurs in a 300 m section within polymictic conglomerate 6 km east-northeast of Magill Lake. The feldspathic greywacke matrix of the conglomerate is lithologically equivalent to sporadic greywacke interlayers (up to 5 m thick) which are gradational with the conglomerate. The greywacke contains detrital quartz and feldspars in a siltstone matrix with biotite generally predominant over hornblende. Garnet and muscovite porphyroblasts occur sporadically in the conglomerates and carbonate is extensively developed at Magill Creek in the conglomerate formation east of McLaughlin Lake (Oxford House area, NTS 53L/14).

The stratigraphic relationship between conglomerate (9b) and mafic volcanic rocks (1b, 1c) east of Magill Lake may be unconformable — the easterly trend of the volcanics is discordant to the projected contact with the conglomerate — but the relationship is obscured by defor-

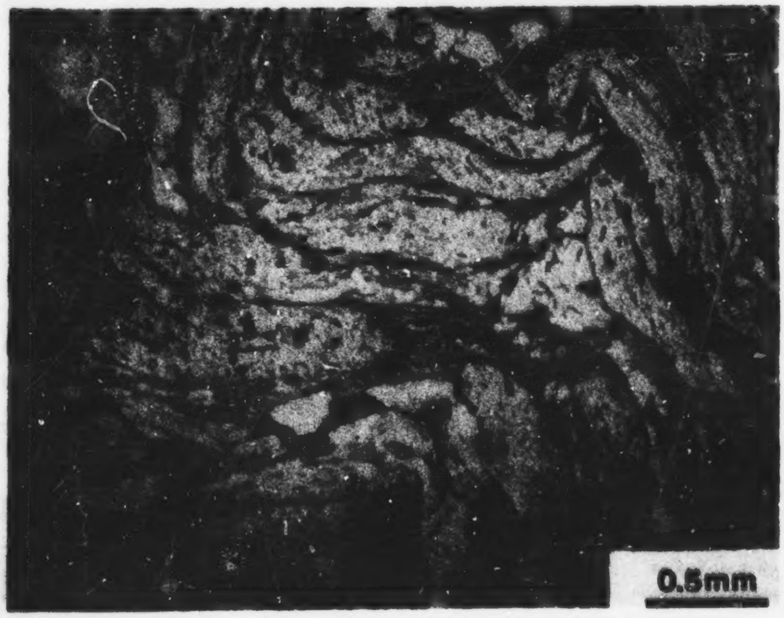


Plate 45: *Folded fragments in conglomerate (9b) at southern Magill Lake; fragments were attenuated during F_2 and later folded during F_3. (Plain light).*

Table 11: Stratigraphic sections at the south and north margins of the volcanic complex (8) at southern Knee Lake — locations 6 and 7, Fig. 10. The northernmost three units at location 7 may be stratigraphically equivalent to a part of the section at location 6 as shown.

	LOCATION 6			LOCATION 7			
	Unit	Lithology	Approximate thickness (m)		Lithology	Unit	
TOPS TO SOUTH		Rocks under water		>10	PYROCLASTIC BRECCIA	8e	TOPS TO NORTH
				> 7	FELDSPATHIC GREYWACKE, CHERT	8g	
				7	TUFF, LAPILLI-TUFF	8e	
	$8c_2$, $8b_2$	PILLOWED PORPHYRITIC ANDESITE, SHOSHONITE	150	5	PILLOWED PORPHYRITIC ANDESITE	$8c_2$	
	8e	PYROCLASTIC BRECCIA	80	>35	PYROCLASTIC BRECCIA	8e	
	8g	FELDSPATHIC GREYWACKE, SILTSTONE, MAFIC GREYWACKE	wedge out east-wards 50				
			30				
	8i	GABBRO	5				
	8g	FELDSPATHIC GREYWACKE	20				
	8h	MAFIC TUFF & LAPILLI-TUFF	7	>15	MAFIC TUFF & LAPILLI-TUFF	8h	
	$8c_1$	PORPHYRITIC ANDESITE	70				
	3h	MAFIC TUFF & LAPILLI-TUFF	20				
	$8c_1$, $8d_1$	FELSIC ANDESITE TO DACITE (wedges out eastwards)	>30				
		Southern contact of the volcanic complex (8) is conformable with feldspathic greywacke (10a).			Northern margin is in fault contact with Hayes River Group rocks (1, 2, 3).		

Table 12: Clast types in conglomerate (9b) — (i) east of Magill Lake, and (ii) north of Jowsey Island, Gods Lake. Assemblages are indicated by crosses in columns at left.

East of Magill Lake	North of Jowsey Island, Gods Lake	Clast type	Notes	Abundance (per cent of total clasts)
X	X	TONALITE, PORPHYRITIC TONALITE	Medium- to coarse-grained, massive to gneissoid, with biotite and green hornblende; quartz phenocrysts (up to 5 mm) occur in hypidiomorphic-granular matrix	generally predominant east of Magill Lake
X	X	QUARTZ-PLAGIOCLASE PORPHYRY	Ovoid quartz and euhedral oligoclase phenocrysts and green hornblende	<10 per cent
X	X	QUARTZ	Angular to ellipsoidal pebbles	rare
X	X	BASALT, AMPHIBOLITE	Aphyric and porphyritic. Microcline porphyroblasts in some amphibolite clasts	<25 per cent assemblage predominant north of Jowsey Island; locally predominant east of Magill Lake
X	X	FELSIC VOLCANIC OR SEDIMENTARY ROCK	Very fine grained quartzofeldspathic rock	
X	X	FELDSPATHIC GREYWACKE	Felsic to intermediate; biotite > hornblende; massive to detrital texture; ± garnet porphyroblasts	
X	X	SILTSTONE, ARGILLITE	Massive to laminated; ± hornblende porphyroblasts	<5 per cent
X		BIOTITE SCHIST	With subhedral plagioclase in a fine grained biotite-plagioclase-hornblende-epidote matrix	<5 per cent
X		CHERT, IRON FORMATION	Alternating magnetite/chert laminae (5 mm - 1 cm)	generally minor, locally predominant
	X	GRANODIORITE, PORPHYRITIC GRANODIORITE AND GRANITE	Medium grained, massive, with biotite and/or hornblende and quartz phenocrysts, microcline megacrysts ± poikilitic sphene. Some clasts contain mafic xenoliths and/or early quartz, pegmatite, or aplite veins	20 to 40 per cent (including tonalite)
	X	MONZONITE	Maroon weathering, with xenomorphic-granular texture, with sutured intergrain boundaries between perthitic feldspars	
	X	GABBRO, QUARTZ GABBRO	Medium grained, massive hornblende-plagioclase rock	<10 per cent

Table 13: Clast types in conglomerate (9c) at Michikanes Lake and the southwest part of southern Knee Lake

CLAST TYPE	NOTES	ABUNDANCE
FELDSPATHIC GREYWACKE	Felsic to intermediate, micaceous, with detrital quartz and plagioclase, and sporadic garnet, hornblende or muscovite porphyroblasts. Some clasts are rich in biotite (up to 40 per cent) or magnetite (up to 10 per cent)	predominant
FELSIC VOLCANIC OR SEDIMENTARY ROCK	Fine grained, quartzofeldspathic rock	
AMPHIBOLITE	Essential fine- to medium-grained green hornblende (or actinolite) and plagioclase; quartz and microcline generally accessory (locally up to 15 per cent each); some clasts are rich in epidote (up to 30 per cent)	subordinate
TOURMALINE	Fine grained, dark blue pebbles in the conglomerate body in the southwest part of southern Knee Lake	rare

mation and contacts are not exposed. The contact between the conglomerate and feldspathic greywacke (10a) to the west is also not exposed, but the two units are interpreted as conformable. The conglomerate east of Magill Lake is the basal unit of the Oxford Lake Group in that area; east of McLaughlin Lake the conglomerate (9b) is 300 m above the base of the Oxford Lake Group, where the basal section consists of feldspathic greywacke (10a) and related schists (10f).

Polymictic conglomerate with volcanic and sedimentary clasts (9c)

Polymictic cobble conglomerate (9c) occurs as major lensoid units (up to 500 m thick) in the southwest part of southern Knee Lake and south of Michikanes Lake; similar conglomerate is interlayered with feldspathic greywacke (10a) south of Opapiskak Narrows. The apparent thickness of the conglomerate body in the southwest part of southern Knee Lake is 2.3 km; this probably has been increased by folding — a synclinal axis occurs in feldspathic greywacke (10a) immediately west of the conglomerate and a parallel, east-trending fold immediately south of the conglomerate is indicated by the outline of an electromagnetic anomaly (QUESTOR airborne aeromagnetic survey, 1978). Volcanic fragmental units have been mapped within this conglomerate by Chastko (1978).

Conglomerate (9c) contains pebbles, cobbles and sporadic boulders of volcanic and sedimentary rocks (Table 13). Clasts are generally ellipsoidal to strongly flattened but original subangular to subrounded shapes are locally preserved; sorting is poor or absent. The feldspathic greywacke matrix is generally micaceous, locally hornblendic, with detrital quartz and plagioclase and sporadic porphyroblasts of garnet and hornblende; similar greywacke occurs as rare interlayers (up to 15 m) within the larger conglomerate units.

Gods Lake Area

METACONGLOMERATE; MINOR METAGREYWACKE (9)

Polymictic volcanogenic conglomerate (9a)

An isolated occurrence of volcanogenic conglomerate (at least 5 m thick) occurs at a small island 1.5 km northwest of Buyers Point, northern Gods Lake (McIvor Lake area, NTS 53L/16). The stratigraphic relationships of the conglomerate are uncertain; the unit is assigned to the Oxford Lake Group on the basis of the lithologic similarity to conglomerate (9c) at southern Knee Lake. The rock contains porphyritic felsic volcanic, mafic volcanic, and micaceous, probably sedimentary clasts (in order of abundance); these are cobble- to small boulder-size (up to 30 x 12 cm). The intermediate to mafic matrix consists of detrital quartz and plagioclase with biotite, epidote, and accessory magnetite, pyrite and sphene. The conglomerate contains sporadic hornblende porphyroblasts and is strongly foliated and attenuated, with extensive chloritic alteration. Pyritiferous siltstone (1 m thick) occurs at the east margin of the conglomerate.

Polygenic conglomerate, minor pebbly greywacke and greywacke (9b)

Polygenic boulder conglomerate outcrops at the southeast shores of several islands 2.5 km north of Jowsey Island (Gods Lake area, NTS 53L/9). Southeast-facing mafic volcanic rocks to the north were apparently eroded before deposition of the conglomerate but the relationship is obscured by shearing. The trend of the contact is roughly parallel to that of the mafic flows. The lateral extent of the conglomerate is at least 1.3 km and the thickness greater than 10 m; the unit is interpreted to overlie the Hayes River Group rocks (1, 2 and 3) in the core of the northeast-trending syncline north of Elk Island.

The conglomerate contains a wide variety of granitoid, volcanic and sedimentary clasts, and is similar to the conglomerate (9b) east of Magill Lake, which contains additional clast types of chert, iron formation and biotite schist. Granite, monzonite, gabbro and quartz gabbro clasts are confined to the locality north of Jowsey Island (Table 12).

The conglomerate north of Jowsey Island is unsorted and clast-supported; the intermediate to mafic greywacke matrix, constituting up to 25 per cent of the rock, is derived from granitoid and mafic volcanic debris. Granitoid clasts (up to 2 m x 1.6 m) are ovoid, well rounded, and locally display joint-bounded faces (Plate 46); mafic volcanic clasts (up to 1.3 m x 0.3 m) are moderately to strongly flattened, and include both massive and well foliated types. Strongly foliated mafic clasts are locally conspicuous within the relatively more massive conglomerate (Plate 47), indicating these clasts were metamorphosed before deposition of the conglomerate. Some mafic clasts are partly altered to epidote and contain pre-depositional veins of epidote, quartz, carbonate and chlorite.

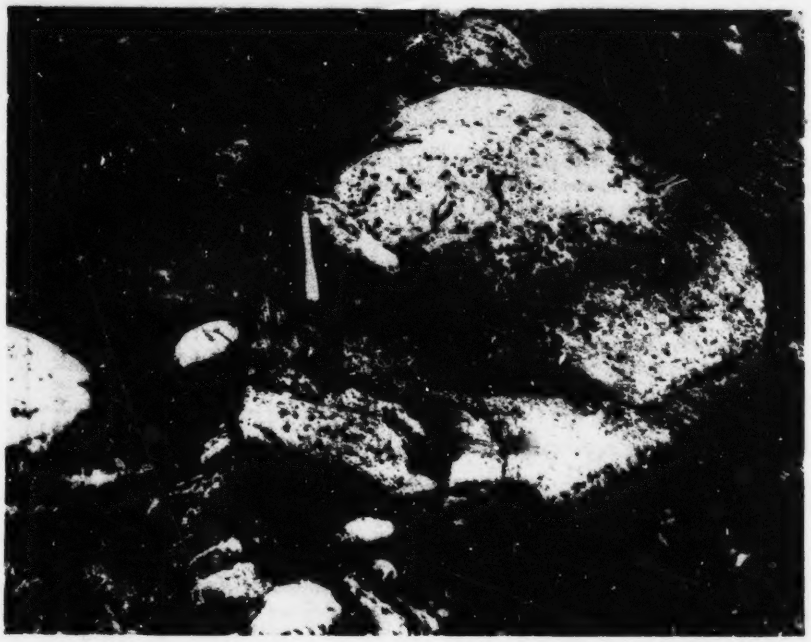


Plate 46: *Conglomerate (9b) with well rounded cobbles and boulders of porphyritic tonalite and granodiorite, sedimentary and volcanic clasts — from Gods Lake. Clasts are considered to be derived from the Bayly Lake Complex and Hayes River Group.*

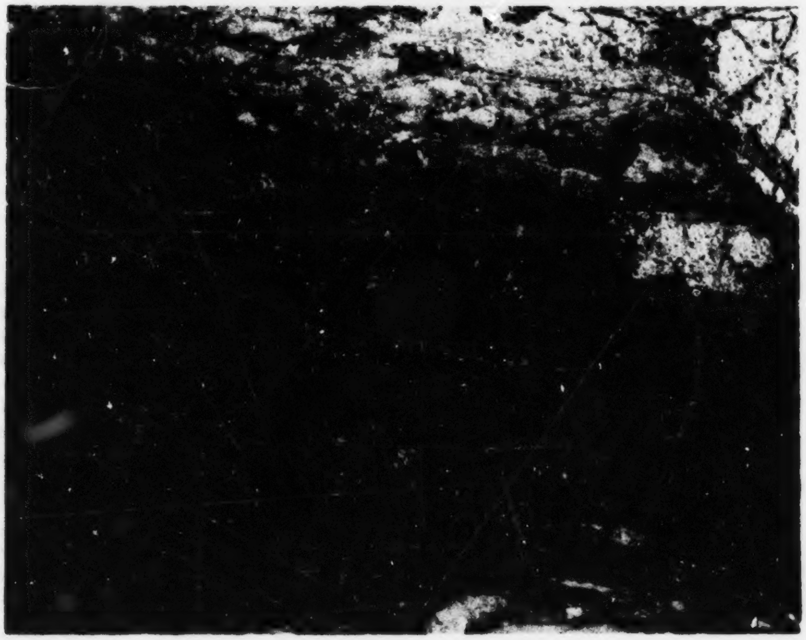


Plate 47: *Conglomerate (9b) with massive granitoid clasts and a well foliated, tabular mafic volcanic block — from Gods Lake.*

Provenance of the Oxford Lake Group conglomerate (9)

The lithologies of many of the volcanic and sedimentary clasts in the Oxford Lake Group conglomerate are comparable to rocks of the Hayes River Group which evidently provided a major source for the younger sediments. Granitoid clasts in the conglomerate are very similar texturally and compositionally to older massive plutonic rocks (Bayly Bay and Elk Island plutons) and gneissoid intrusives in the Brown Lake-western Gods Lake granitoid complex (Figs. 4a, 7, 8 and 14 and Table 12). The granodioritic and granitic clasts in the boulder conglomerate north of Jowsey Island are probably derived from the adjacent Bayly Bay pluton (granodiorite to granite) to the northwest; clasts of this composition are not known in the Oxford Lake Group conglomerate elsewhere. Granitoid clasts are tonalitic in the conglomerates east of Magill Lake and at Gods Lake Narrows; data from the latter locality, which was mapped by B. Marten, are included in Figure 14 for comparison. Tonalitic phases in the Elk Island pluton, and the granitoid terranes west of Gods Lake and south of Gods Lake Narrows represent the probable sources of these clasts. Monzonite cobbles at the locality north of Jowsey Island are probably derived from an intrusion related to the Bayly Bay pluton; granitoid rocks of similar composition have been mapped within a related intrusion at Cinder Lake 8 km northwest of the Bayly Bay pluton (Knee Lake area, NTS 53L/15).

Southern Knee Lake-Magill Lake Area

METAGREYWACKE, META-ARENITE; MINOR METAPELITE, AMPHIBOLITE, PARAGNEISS (10)

Feldspathic greywacke, minor pebbly greywacke, lithic wacke, argillite and iron formation (10a)
Arenite, arkosic wacke (10b)
Garnet-, andalusite-, staurolite- and cordierite-bearing schists and gneisses (10f)
Iron formation (10g)

Feldspathic greywacke is the predominant lithology in the extensive area underlain by Oxford Lake Group sedimentary rocks extending from the eastern part of Oxford Lake to the south shore of Hawkins Lake (Oxford House, Knee Lake and Vermilyea Lake areas — NTS 54L/14, 15 and 10 respectively). The greywacke is locally intercalated with conglomerate (9b, 9c) and amphibolite (10d) and is intruded by tonalitic rocks (6a) at the contact with the gneiss complex to the south; the greywacke is in conformable contact with the older volcanic complex (8) to the north.

The majority of the greywackes sampled are feldspathic wacke in composition (Fig. 15). Lithic greywacke and minor arkosic rocks occur locally in association with intercalations of conglomerate, and arkosic wacke (10b) occurs with feldspathic greywacke at the south shore of Hawkins Lake. Pale- to medium-grey feldspathic greywacke is massive to poorly bedded at a scale of 0.1-1 m (locally 1-10 cm). Some beds contain very fine micaceous trails parallel to the bedding; sporadic pebbles occur in greywacke adjacent to conglomerate interlayers. Trough-shaped cross-beds (15-20 cm thick) are well developed at Knife Rapids and Trout Falls (Plate 48); poorly preserved cross-bedding also occurs south of Opapiskak Narrows. Graded bedding is developed in interlayered greywacke and siltstone at the north end of Michikinabish Lake and at McLaughlin Lake; the siltstone is partly reworked into the greywacke beds. The regional foliation of the fine grained sedimentary rocks, defined by biotite (± green hornblende), is parallel to the bedding. Quartzofeldspathic veins are common within these rocks; early concordant veins are isoclinally folded and disrupted, and cut by younger concordant to discordant veins and later quartz-tourmaline-filled fractures.

Porphyroblastic schist and gneiss (10f) occur as subordinate interlayers within the sedimentary section. Andalusite (up to 3 cm) occurs in 10-30 cm thick schist layers south of Opapiskak Narrows. Almandine- and/or cordierite-bearing interlayers (up to 50 cm thick) are characteristic of a narrow zone (15-30 m) extending from the south shore of McLaughlin Lake for approximately 10 km to the east (Plate 49).

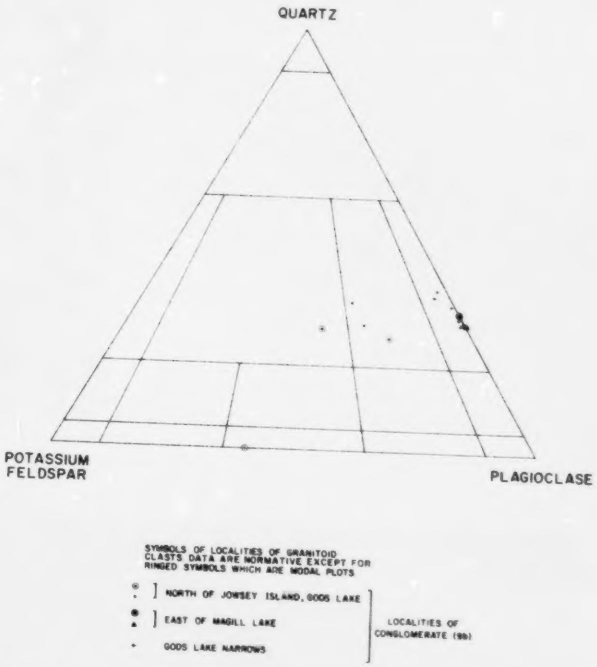


Figure 14: *Potassium feldspar-quartz-plagioclase analyses of granitoid clasts in conglomerate (9b). Compositional fields are shown in Fig. 4b.*

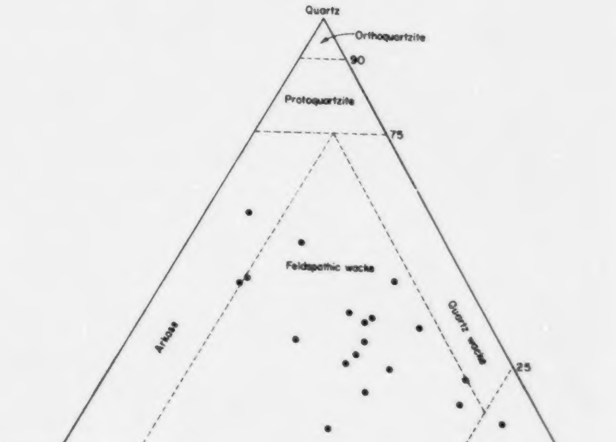


Figure 15: *Feldspar-quartz-matrix ternary plot of analyses of sedimentary rocks (10a) — 1000 point-counts per thin section.*

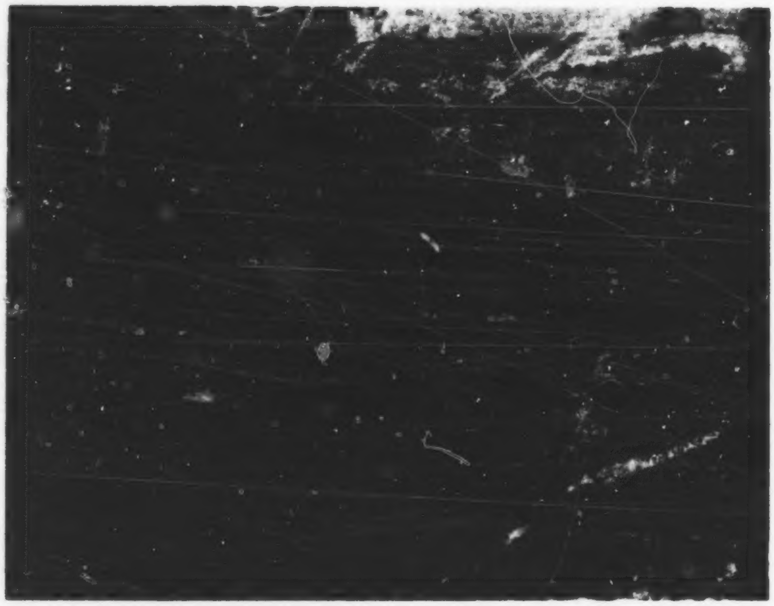


Plate 48: Cross-bedded feldspathic greywacke (10a) at Trout Falls, Hayes River.

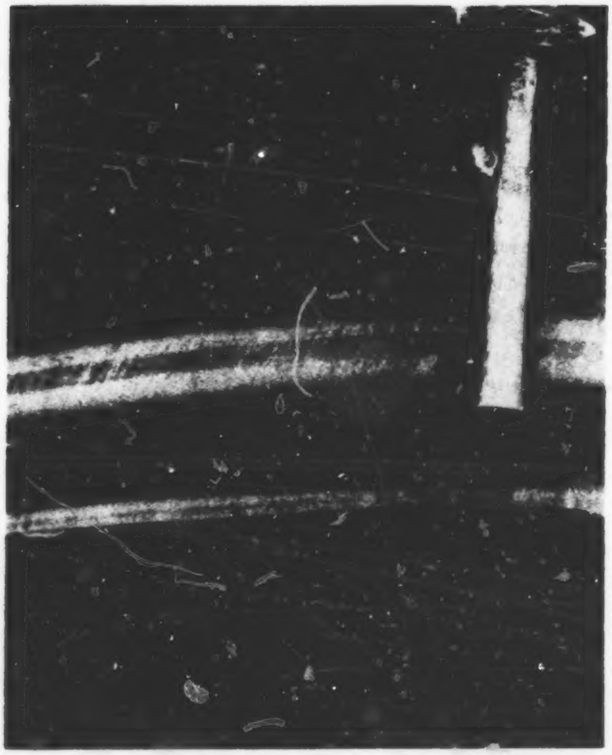


Plate 49: Well bedded, fine grained metasedimentary rocks (10f) at McLaughlin Lake; porphyroblasts of garnet and altered cordierite occur in the darker, more pelitic interlayers. Lineations transecting the bedding are glacial striations.

Garnet- and/or hornblende-rich strata are common within feldspathic greywacke (10a) at Michikanes Lake and in the southwest part of southern Knee Lake. Garnet constitutes up to 50 per cent of some beds. Rare tourmaline-rich laminae (0.1-1 cm) occur south of Opapiskak Narrows and at the south shore of McLaughlin Lake. The following assemblages occur in feldspathic greywacke and schist (10a, 10f):

1. Biotite-garnet (± green hornblende or cummingtonite or anthophyllite).
2. Biotite-staurolite.
3. Biotite-muscovite-cordierite.
4. Biotite-muscovite-microcline
5. Biotite-muscovite-andalusite (± sillimanite)

All assemblages include andesine (less commonly, labradorite) and quartz.

Iron formation (10g), locally associated with porphyroblastic schist (10f), occurs at the south shore of Hayes River (east of Trout Falls) and between Knife Rapids and Trout Falls (Oxford House area, NTS 53L/14). East of Trout Falls, magnetiferous argillite is interlayered with staurolite-garnet schist at a scale of 1-15 cm; the argillite contains up to 50 per cent magnetite in fine laminae (0.5-3 mm). Approximately 1 km further east a small reef roughly on-strike with the iron formation consists of at least 15 m of alternating chert, pyritiferous siltstone, and magnetiferous amphibolite layers (0.5-4 cm thick) with abundant garnet; 6.5 km further east the iron formation (10 m thick) is comprised of interlayered chert and magnetiferous siltstone laminae (0.1-1.5 cm thick). Chert, magnetiferous siltstone and garnetiferous amphibolite occur in a 65 m section containing minor pyrite-arsenopyrite stringers at Michiskun Narrows (southern Knee Lake). The section corresponds to a positive electromagnetic anomaly trending east-southeast and deformed in a fold closing further to the east (QUESTOR airborne aeromagnetic survey, 1978).

The feldspathic greywacke is largely recrystallized with the loss of most primary textures during development of the biotite (± green hornblende) foliation. However, detrital quartz and feldspar are locally preserved; sporadic fragments of granitoid rocks, felsic porphyry, and mafic lithologies are not uncommon in lithic wackes associated with conglomerate (9b, 9c). Plagioclase (generally andesine, ranging from albite to labradorite) is commonly zoned and antiperthitic; rare myrmekitic fragments are probably of granitoid origin. Detrital microcline is prominent at Hawkins Lake and occurs locally in the area to the northwest.

Porphyroblasts occurring in the greywacke and related schist include biotite, green hornblende, garnet and (less common) staurolite, cordierite, andalusite, anthophyllite, cummingtonite, muscovite and chlorite. Hornblende occurs as pre-tectonic, rotated blasts and later, post-tectonic types which overprint the foliation. Pre-tectonic, helicitic garnets contain an internal foliation (of quartz-feldspar-cummingtonite and magnetite) discordant to the regional micaceous foliation. Syn-tectonic garnets include rotational* blasts and elongate crystals parallel to the regional foliation, which are deformed by later folds. Post-tectonic garnets overprint the folds. Syn-tectonic staurolite poikiloblasts are rotational, and locally occur with later plagioclase blasts which overprint the foliation. Cordierite poikiloblasts locally display progressive deformation of inclusions — those at the rims are more strongly aligned to the external foliation than inclusions in the cores of the blasts (Plate 50), indicating cordierite development extended from early- to syn-tectonic stages. The blasts are generally completely altered to pinite or muscovite pseudomorphs. Younger aggregates of quartz ± muscovite ± magnetite ± chlorite are developed in cordierite strain-shadows. Andalusite xenoblasts and rare anthophyllite, which overprint the regional foliation, have been rotated by later movement; andalusite is partly altered to sericite and locally contains rare, randomly oriented sillimanite. Cummingtonite is parallel to the regional foliation or occurs in the strain-shadows of earlier garnet porphyroblasts. Muscovite and chlorite occur as laths parallel to the regional foliation and as post-tectonic porphyroblasts. Common accessories include epidote, magnetite, pyrite, sphene, ilmenite, blue to yellow tourmaline, pink to beige apatite and zircon. Clinopyroxene is a rare accessory in calcareous metasediments in the pendant structure within the Magill Lake pluton (11). Carbonate is widespread, and locally occurs as a replacement of plagioclase or pseudomorphs after hornblende.

The foliation of the greywacke is locally folded with associated strain-slip cleavage and/or axial-planar development of hornblende, garnet or chlorite. Late retrogressive metamorphism resulted in widespread chlorite, sericite, epidote and sporadic stilpnomelane. Quartzofeldspathic veinlets (± carbonate ± tourmaline ± pyrite) postdate the alteration.

Amphibolite (10d)

Amphibolite is locally interlayered with feldspathic greywacke (10a) in the southwest part of southern Knee Lake, and at Michikanes Lake. Amphibolite layers (1-5 m thick, up to 20 m) are homogeneous or laminated with strata-bound garnet or gneissic layers defined by variable contents of hornblende, epidote, cummingtonite or quartz and feldspar. Quartz is generally minor, but locally abundant (up to 30 per cent). The fine- to medium-grained amphibolite is locally pyritiferous and iron stained. Gradational contacts with feldspathic greywacke and the local occurrence of significant quartz and well developed compositional layering in the amphibolite indicate a sedimentary (rather than igneous) origin. The following assemblages occur in amphibolite:

1. Green hornblende ± biotite ± epidote.
2. Green hornblende-garnet (± biotite ± cummingtonite).
3. Green hornblende-clinopyroxene (± garnet).

All assemblages include andesine (less commonly labradorite) and quartz.

The amphibolite consists of essential green hornblende and plagioclase (up to An_{70}) with sporadic cummingtonite and variable quartz contents. Accessories include microcline, biotite, sphene, zircon and opaque minerals. Hornblende defines the foliation and also occurs as randomly oriented poikiloblasts; the amphibole is locally recrystallized parallel to the axial planes of minor folds. Elongate garnets parallel to the foliation are deformed by these folds (Fig. 16 and Plate 51); some garnets are helicitic, with internal microfolds defined by tremolite.

---

*Rotational: "structure ... preserved in certain minerals which are rotated by tectonic movements at the same time as they grow ... not synonymous with 'rotated' meaning rotated after formation." (Spry, 1969).

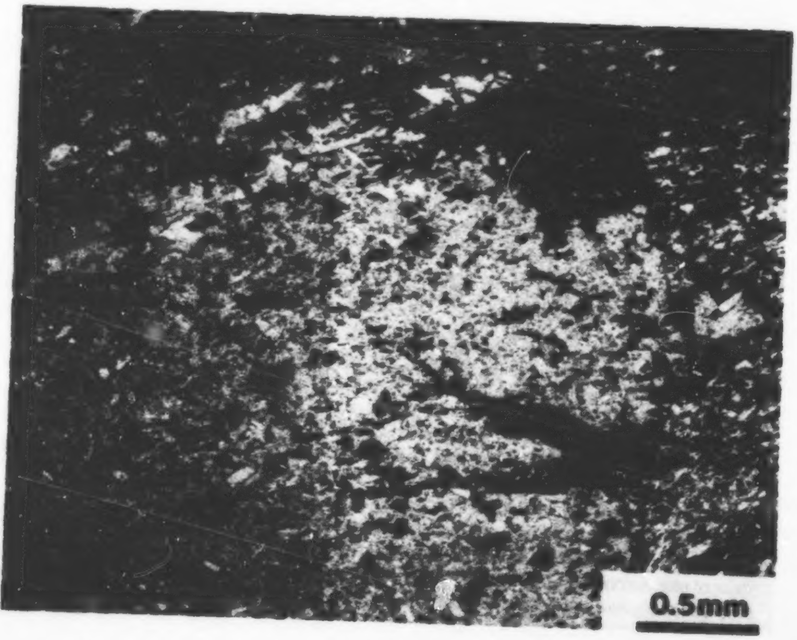


Plate 50: *Cordierite-biotite-muscovite schist (10f) from Magill Creek; cordierite poikiloblast is partly altered to pinite and is overgrown by later chlorite (lower right). (Crossed nicols).*

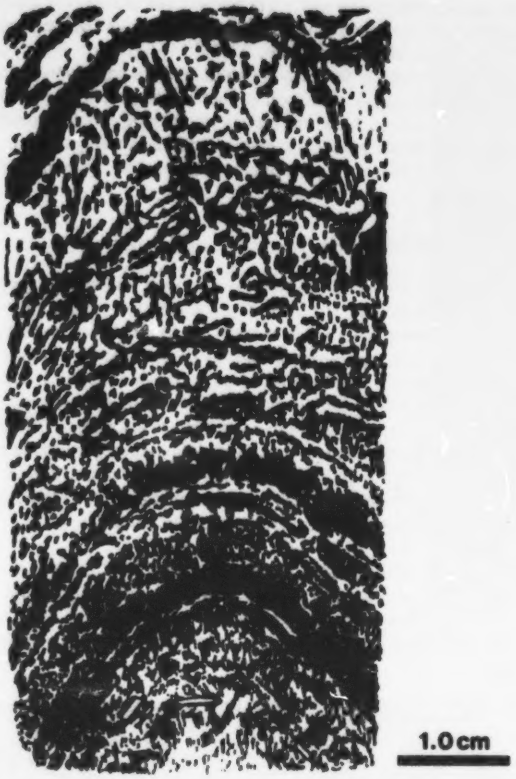


Figure 16: *Garnetiferous amphibolite (10d) — folded foliation (green hornblende-garnet-plagioclase-quartz) with later weak axial-planar foliation (green hornblende). Details of garnets (open ovoid forms close to base) are shown in Plate 51. Reproduced from a thin section from Michikanes Lake. Black = green hornblende (and minor biotite); white = quartz and feldspar.*

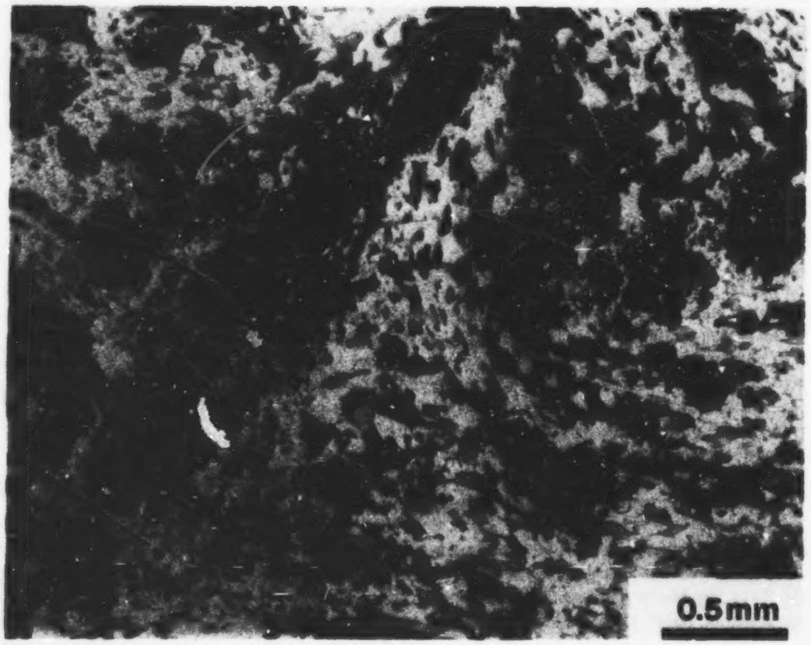


Plate 51: *Amphibolite (10d) showing details of a folded garnetiferous layer; elongate garnets, parallel to the regional hornblende-biotite foliation have been partly rotated during deformation of the foliation by F_3. The photomicrograph is of part of the rock illustrated in Figure 16 — from Michikanes Lake. (Plain light).*

POST-OXFORD LAKE GROUP INTRUSIVE ROCKS

METAGRANODIORITE (11)

Granodiorite, porphyritic granodiorite and granite (11a)
Pegmatite (11b)

MAGILL LAKE PLUTON

The Magill Lake pluton is emplaced within metasedimentary rocks (9, 10) approximately 10 km south of southern Knee Lake. The pluton and an adjacent ovoid stock to the east consist of granite to granodiorite (Fig. 17); related coarse grained to pegmatitic dykes are abundant between Magill Lake and southern Knee Lake.

The white to pink granitoid rocks are massive to slightly gneissoid with hypidiomorphic-granular texture. Some sharply defined pegmatitic zones suggest the occurrence of a discrete pegmatitic phase, but elsewhere these zones are gradational with the predominantly medium- to coarse-grained rocks of the pluton. Minor garnet is common and tourmaline occurs as sporadic prisms (up to 2 cm) or fine grained schlieren. Irregular layering (0.5-4 cm) defined by grain size, microcline/plagioclase ratio, and/or garnetiferous zones was observed at a few places. Some garnet trails are irregularly folded with an axial-planar foliation of attenuated quartz and feldspar.

Sporadic xenoliths of foliated feldspathic greywacke (10a) up to several metres long trend roughly east-west, parallel to the incipient foliation of the pluton; the xenoliths contain boudined granitoid veins. An enclave of feldspathic greywacke (10a) at the central peninsula of Magill Lake is characterized by slightly higher metamorphic grade (hornblende hornfels facies) than equivalent rocks external to the pluton.

The Magill Lake pluton contains abnormally high Rb (8 samples range from 238 to 692 ppm Rb) and a high degree of fractionation is inferred (Černý, 1983); the associated pegmatites therefore have a potential for rare-element mineralization.

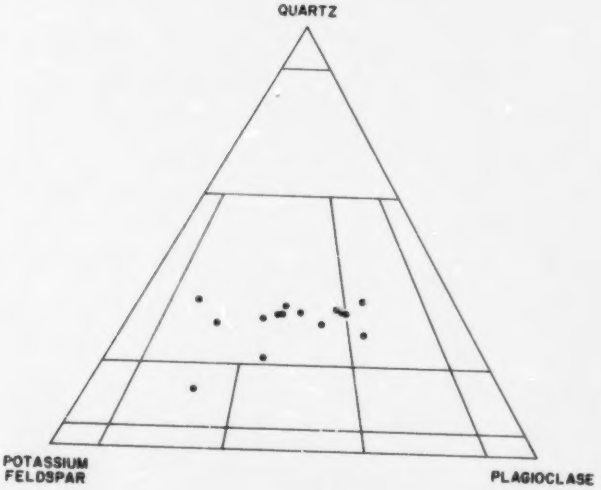


Figure 17: Potassium feldspar-quartz-plagioclase modal analyses of the Magill Lake pluton (11). Compositional fields are shown in Fig. 4b.

MINOR INTRUSIONS

Minor tonalitic to granitic intrusions related to the Magill Lake pluton are abundant in the greywacke terrane (10a) within 8 km of the pluton. These bodies are massive to slightly foliated, medium grained to pegmatitic, and generally undeformed except close to the south margin of the pluton, where dykes are isoclinally folded and disrupted by movement parallel to the pluton margins (Plate 52). This deformation distinguishes the pegmatite dykes (11b) from pegmatites in the gneiss complex to the south (6e); these units are also distinguished by colour (white for 11b, pink for 6e) and mineralogy (relatively more common garnet in 11b, and coarser grain size of tourmaline in 6e).

Spodumene crystals up to 15 cm long occur in a 1.5 m wide concordant pegmatite body in the southeast part of McLaughlin Lake (Oxford House area, NTS 53L/14). The intrusion (albite-granodiorite) also contains tourmaline, garnet, muscovite and cordierite. The most coarse grained intrusion encountered in the pegmatite suite (11b), which occurs at southern Knee Lake, 3.5 km south-southeast of Opapiskak Narrows, contains perthitic microcline up to 30 cm across and biotite blades up to 6 cm long. Minor dykes of foliated plagioclase-porphyry (up to 50 cm thick), which occur in the vicinity of the pluton, are probably related to the main intrusion.

The granitoid rocks contain plagioclase (generally albitic, locally more calcic in minor intrusions, up to An_{35}), which is zoned, antiperthitic, and displays deformation-twinning. Early microcline occurs as inclusions within plagioclase, which is replaced by younger perthitic microcline, itself surrounded by later myrmekitic rims. Granophyric quartz-feldspar intergrowths are characteristic of coarse grained phases. Micas include dark brown biotite (locally with bleached cores), muscovite (up to 2 cm) in pegmatites, and a very pale brown, slightly pleochroic mica. Spodumene at McLaughlin Lake displays polysynthetic twinning and contains vermicular quartz. Minor accessories include allanite (with metamict rims), green hornblende, magnetite, epidote, and rare pyrite. One dyke at southern Knee Lake contains axinite. Chloritic and sericitic alteration, straining of quartz, and slight deformation of feldspars and micas are common.

METAGABBRO AND METADIABASE (12)

Porphyritic diabase (12b)

Diabase dykes trending east-northeast to southeast, which postdate pegmatite (11b), intrude the Oxford Lake Group and older rocks. A typical dyke south of Opapiskak Narrows (southern Knee Lake) is dark grey, massive, and displays randomly oriented plagioclase in altered ophitic texture with green hornblende; the diabase contains remnants of clinopyroxene and two phases of plagioclase — bytownite as stubby phenocrysts (2-3 mm) and labradorite as smaller, anhedral elongate laths; hornblende is partly altered to very fine grained biotite and chlorite.

Several mafic dykes (up to 7 m thick) with prominent hornblende pseudomorphs intrude conglomerate (9b) at a small lake 5 km east-northeast of Magill Lake (Knee Lake area, NTS 53L/15) and similar dykes occur in greywacke (10a) at Opapiskak Narrows (Oxford House area, NTS 53L/14). The dykes near Magill Lake, which are slightly discordant to the host rock foliation, contain up to 35 per cent green hornblende (pseudomorphic after pyroxene) which is partly altered to biotite or chlorite (± epidote ± carbonate — Plate 53). The intermediate to mafic matrix is massive to slightly foliated. Accessories include microcline, quartz, sphene, apatite, pyrite and dark blue tourmaline.

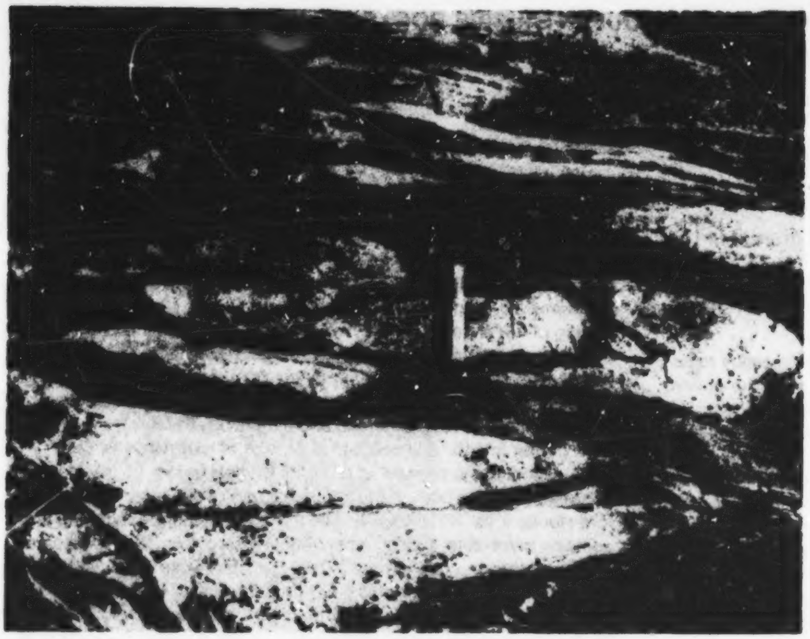
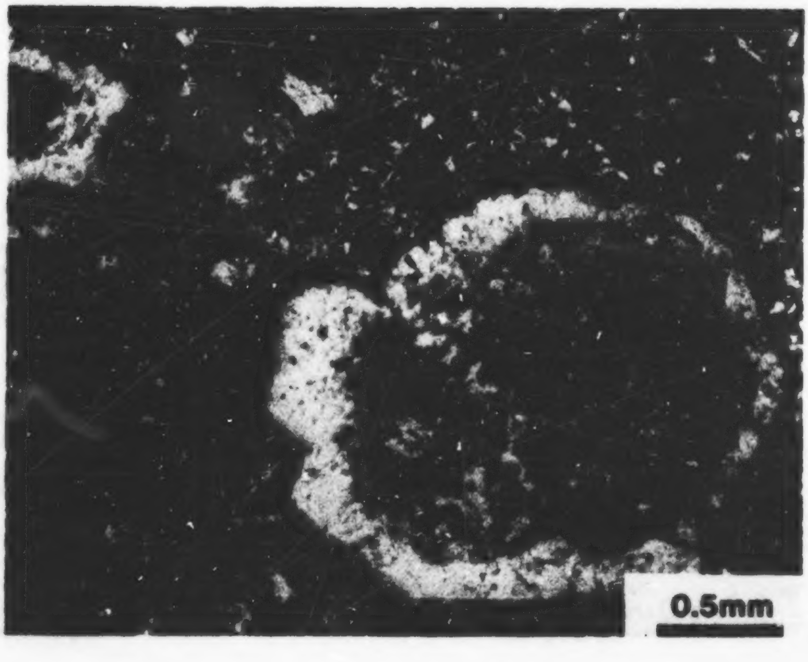


Plate 52: *Folded and disrupted pegmatite dykes (11b) close to the south margin of the Magill Lake pluton.*

Plate 53: *Porphyritic diabase dyke (12b) with hornblende pseudomorphs after pyroxene, partly altered to biotite, in a fine grained hornblende-biotite-feldspar-epidote matrix. The dyke intrudes conglomerate (9b) in the area east of Magill Lake. (Crossed nicols).*



Porphyritic diabase similar to the dykes near Magill Lake intrudes conglomerate (9a) at the small island 1.5 km northwest of Buyers Point (McIvor Lake area NTS 53L/16). The dyke is well foliated, discordant to the conglomerate foliation, and contains hornblende euhedra in a medium grained albite-biotite-hornblende matrix.

GABBRO AND DIABASE (13)

Diabase, porphyritic diabase (13c)

Massive diabase dykes, which trend north or northeast (less commonly northwest), occur sporadically between Oxford Lake and Gods Lake. These dykes are part of the Molson and Mackenzie dyke swarms (Fahrig et al., 1965; Scoates and Macek, 1978). The intrusions, which occur singly or in *en echelon* groups (up to 6, at least), are undeformed except for very minor late faulting. The largest dyke exceeds 20 m but most intrusions are less than 1 m thick. The grey- to beige-weathering dykes commonly display narrow (1-5 cm) chilled margins. Prominent linear aeromagnetic anomalies are associated with the larger intrusions (Map 7294G, Oxford House, Federal-Provincial Aeromagnetic Series).

The diabase consists of essential clinopyroxene and labradorite, associated with olivine or accessory quartz. Plagioclase in the matrix, which is zoned (normal and oscillatory), ranges up to An$_{62}$, and phenocrysts up to An$_{70}$. Colourless to very pale green or pale brown clinopyroxene is generally fine grained, but locally occurs in aggregates or as sporadic anhedral grains up to 1 cm; ophitic texture is widespread. Phenocrysts provisionally identified as pigeonite occur in several dykes north of Buyers Point (McIvor Lake area, NTS 53L/16). Corrosion textures indicate that most plagioclase preceded clinopyroxene and olivine, but a later plagioclase phase postdates idiomorphic olivine. Quartz is intersertal and locally forms granophyric intergrowths with perthitic feldspar. Disseminated magnetite (or ilmenite) constitutes up to 5 per cent of the rock; some dykes contain prominent intersertal ilmenite (with leucoxene). Pyrite and sphene are minor accessories. The diabase is generally slightly altered (5-10 per cent), and several dykes are completely altered. Antigorite and talc occur within olivine, pyroxene is replaced by uralite or chlorite, or muscovite and epidote, and plagioclase is sericitized and saussuritized.

METAMORPHIC HISTORY

Three regional metamorphic events have been recognized in both the Hayes River Group (1-3) and Michikinabish Lake-Brown Lake gneiss complex (6) as shown in Tables 14 and 7). The earliest metamorphism (M_1) apparently predated the Cxford Lake Group, which provides evidence for only two metamorphic events. These conclusions are consistent with the metamorphic history described by Hubregtse (1985) in the Oxford Lake-Carrot River area, except for the treatment of the final retrogressive greenschist facies metamorphism (M_3) which is described as a late M_2 alteration by Hubregtse.

Regional metamorphism at upper greenschist to middle amphibolite facies grade has affected all rocks in the area, except for some dykes of unit 13. Field relationships indicate that the Hayes River Group rocks were metamorphosed before emplacement of the Bayly Lake Complex and deposition of the Oxford Lake Group. Xenoliths of strongly foliated pillow basalt and gneissic amphibolite derived from the Hayes River Group occur in unit 4 at northeastern Gods Lake (Plates 28 and 29) and within the Elk Island pluton (7). Similar foliated basaltic rocks occur as clasts in the basal Oxford Lake Group conglomerate (9b); in both cases the mafic fragments have been metamorphosed prior to incorporation in the host rock. Petrographic evidence for a pre-Oxford Lake Group metamorphism is provided by volcanic fragmental rocks (2b) of the Hayes River Group east of Knife Lake which have been subjected to three metamorphic events. Further evidence for three events occurs at Oxford Lake, where Hubregtse (1985) describes overprinting of metamorphosed Hayes River Group rocks by later amphibolite facies metamorphism (M_2) and truncation of M_1 regional metamorphic zones by M_2 zones. Overprinting of the M_1 mineral assemblages only occurred where M_2 attained amphibolite facies grade (Hubregtse, op. cit.).

M_1 resulted in a regional foliation in the Hayes River Group defined by green hornblende (± biotite). Primary clinopyroxene and labradorite are preserved in several synvolcanic gabbros but the rocks of the Hayes River Group have generally been completely recrystallized. Kyanite relicts (M_1) are preserved within cordierite blasts (M_2) in intermediate volcanic fragmental rocks (2b) east of Knife Lake (Gods Lake area, NTS 53L/9) as shown in Plate 54. These volcanic rocks have been recrystallized to sillimanite-cordierite-biotite gneiss and anthophyllite-cordierite-biotite gneiss during M_2. Porphyroblasts (M_2) in metasedimentary rocks (3a) at Gods Lake also include garnet, andalusite, staurolite, biotite, muscovite, green hornblende and cummingtonite; these are late- or post-tectonic (randomly oriented) except for andalusite, which is parallel to the foliation. Rare anthophyllite blasts define an incipient foliation discordant to S_1. Intermediate to mafic metavolcanic rocks consist essentially of green hornblende, oligoclase-andesine, and minor quartz (± biotite ± rare garnet).

Later retrogressive metamorphism (M_3) in the greenschist facies has affected the Hayes River Group throughout the Knee Lake-Gods Lake area. Alteration products include sericite, saussurite, chlorite, tremolite and sporadic stilpnomelane and prehnite; chlorite is locally porphyroblastic or defines a late strain-slip cleavage. Carbonatization, granulation and shearing are commonly associated with the retrogressive metamorphism.

The metamorphic history of the Michikinabish Lake-Brown Lake gneiss complex (6) is comparable to that of the Hayes River Group (Table 7). Poikiloblasts of hornblende and plagioclase (M_2) in the tonalitic gneisses contain relicts of an earlier biotite-plagioclase-quartz assemblage (M_1) which is interpreted to be the same age as the gneissic layering and earliest foliation. Regional migmatization and blastesis (M_2) was followed by retrogressive metamorphism (M_3).

Gneissoid and massive granitoid rocks (4, 7) consist largely of primary igneous assemblages; minor layered gneisses in unit 4a may

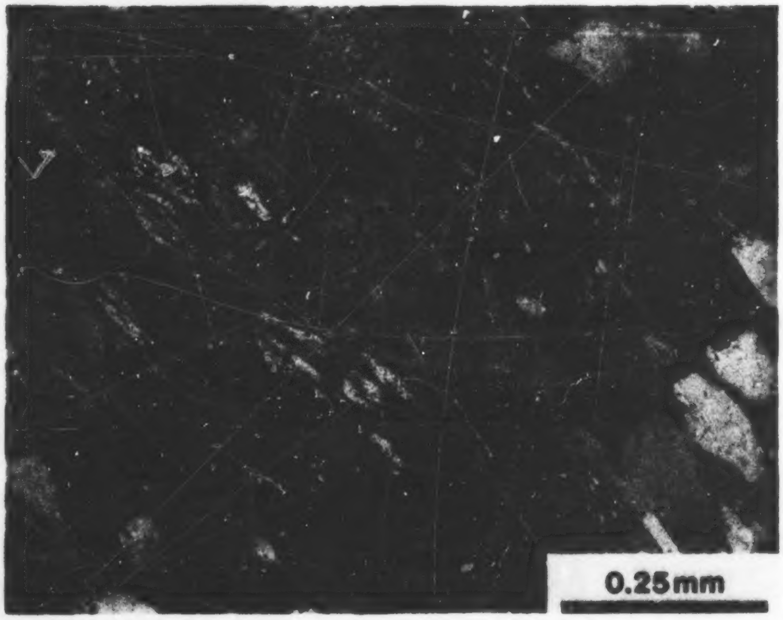


Plate 54: Kyanite relict within cordierite (associated with biotite, plagioclase and quartz) in intermediate volcanic fragmental rocks (2b) close to the south margin of the Elk Island pluton (7). (Crossed nicols).

Table 14: Tectonic and metamorphic histories of the Hayes River and Oxford Lake Groups

	DEFORMATION	METAMORPHISM	
F_1	Inferred deformation associated with early metamorphism (M_1). Gods Lake area: major tight to isoclinal folding of primary layering. Trend varies from NE to SE. Southern Knee Lake area: monoclinal section established (Hayes River Group).	Regional metamorphism (upper greenschist to amphibolite facies) inferred from: (1) Green hornblende-oligoclase (-andesine) foliation in mafic volcanic rocks (Hayes River Group) occurring as xenoliths in granitoid intrusions (4, 6, 7), and clasts in conglomerate (9b). (2) Kyanite occurrence in unit 2b.	M_1
	EMPLACEMENT OF MAJOR GRANITOID INTRUSIONS — BAYLY LAKE COMPLEX (4, 6, 7) DEPOSITION OF OXFORD LAKE GROUP VOLCANIC AND SEDIMENTARY ROCKS (8, 9, 10)		
F_2	Major tight to isoclinal folding. Gods Lake area: inferred tightening of earlier F_1 structures. Southern Knee Lake area: moderately to steeply plunging folds with ENE to ESE trend.	Regional metamorphism (lower to middle amphibolite facies) and foliation (biotite and/or green hornblende; less commonly tremolite or muscovite). Greywacke and porphyroblastic schists (3a, 10a, 10f) contain garnet, green hornblende, cummingtonite, anthophyllite, cordierite, staurolite, andalusite and rare sillimanite.	M_2
F_3	Closed to tight folding of regional foliation in moderately to steeply plunging folds with generally ENE to ESE trend and moderately to steeply dipping axial planes roughly parallel to the regional foliation. Local development of weak axial-planar foliation or strain-slip cleavage in cores of minor folds; mineral lineation and clast elongation in fragmental rocks and local microcrenulation, rodding, and boudinage (L3).		
F_4	Closed folding in subhorizontal folds with roughly vertical axial planes normal to F_3 folds.		
D_5	Shearing and brittle fracturing parallel and discordant to the regional foliation. Local development of chlorite-muscovite strain-slip cleavage.	Regional metamorphism (greenschist facies; locally, in Gods Lake area, prehnite-pumpellyite-quartz facies). Recrystallization of hornblende to finer grained aggregates. Alteration to assemblages including tremolite, biotite, chlorite, albite, epidote, muscovite and carbonate; sporadic occurrences of stilpnomelane and prehnite.	M_3

Table 15: Tectonic stages of M_2 porphyroblasts in feldspathic greywacke and schist (10a, 10f).

	Tectonic stage				
	Pre	Early	Syn	Late	Post
Garnet	——	——	——	——	——
Green hornblende	——	——	——	——	——
Biotite		——	——	——	——
Cordierite		——	——		
Anthophyllite		——	——	— — ?	— — ——
Staurolite			——		
Plagioclase			——	— — ?	— — ——
Muscovite			——	— — ?	— — ——
Andalusite			——	— — ?	— — ——
Cummingtonite				——	——
Sillimanite					——

have been produced during the earliest metamorphism (M_1) in the gneiss complex (6). The local development of green hornblende and calcic oligoclase porphyroblasts in the granitoid rocks is possibly contemporaneous with M_2 in the gneiss complex. Retrogressive metamorphism has also affected the granitoid rocks, but is less pervasive than in the Hayes River Group.

Mafic dykes (4h, 4i, 7h and 12b) provide evidence of only two metamorphic events. These rocks consist largely of green hornblende and oligoclase-andesine, attributed to M_2; later greenschist facies alteration (M_3) has also affected the mafic dykes, but there is no evidence of M_1. Remnants of primary clinopyroxene partly altered to hornblende occur in some dykes. The youngest mafic dykes (13c) are characterized by variable alteration of primary minerals to chlorite, epidote, sericite and uralite. It is unknown whether this is a late hydrothermal process during emplacement or a result of regional metamorphism.

The Oxford Lake Group has apparently been affected by only two metamorphic events, probably corresponding to M_2 and M_3 in the Hayes River Group. M_2 attained the middle amphibolite facies and resulted in porphyroblast development in the semi-pelitic rocks of unit 10 extending from pre- to post-tectonic stages (Table 15). Porphyroblasts include both rotated (pre-tectonic) and rotational (syn-tectonic) types; post-tectonic blasts are randomly oriented. Polygonization of micas occurred locally where the foliation is deflected round early porphyroblasts. Helicitic garnets in several rocks contain an internal foliation of quartz-feldspar-cummingtonite-magnetite attributed to an early stage of M_2, but this assemblage may be a product of an earlier metamorphic event which has not been recognized elsewhere in the Oxford Lake Group. The regional foliation resulting from M_2 is defined by biotite, green hornblende or locally muscovite or rare tremolite.

Later M_3 retrogressive metamorphism (greenschist facies) resulted in the recrystallization of hornblende to finer aggregates or alteration to tremolite; development of porphyroblastic chlorite, muscovite pseudomorphs (after andalusite or cordierite) and carbonate pseudomorphs (after hornblende); alteration of clinopyroxene to tremolite, andesine to albite, and biotite to stilpnomelane; and the widespread development of sericite, saussurite, clinozoisite, biotite, and chlorite as alteration products of earlier (M_2) porphyroblasts. The retrogression is locally associated with carbonatization, shearing and granulation, microcrenulation, and the development of a strain-slip chlorite-muscovite foliation.

Assemblages in porphyritic diabase (8i) indicate a slightly higher metamorphic grade during M_2 in the area south of Michikanes Lake than at southern Knee Lake; the later (M_3) metamorphism however was relatively more pervasive at southern Knee Lake.

Metamorphic Facies

The conditions during M_1 can be inferred from the upper greenschist to amphibolite facies assemblages of mafic xenoliths of the Hayes River Group within intrusions of the Bayly Lake Complex, and basaltic clasts in the basal Oxford Lake Group conglomerate. The foliations of these mafic fragments, which predate their host rocks, are defined by green hornblende and oligoclase-andesine. Kyanite relicts (M_1) within M_2 cordierite east of Knife Lake indicate relatively high pressures (> 5 kb) characteristic of the Barrovian-type facies series. A second occurrence of kyanite occurs in biotite-quartzite at southern Oxford Lake (Hubregtse, 1985).

M_2 attained middle amphibolite facies grade at intermediate pressure. Cordierite and andalusite are characteristic of the Abukuma series of intermediate pressure (3-5 kb). However, slightly higher pressures are indicated by the co-existence (in units 10a and 10d) of garnet and green hornblende—a common assemblage in the higher pressure Barrovian series, but excluded from the Abukuma-type metamorphism. Garnet and muscovite have not been observed to coexist, except where the latter is a product of the later retrogressive metamorphism; this incompatibility is encountered in the Abukuma facies series, but does not occur in the Barrovian (Winkler, 1967). At intermediate pressures, the co-existence of garnet and cummingtonite is characteristic of the upper part of the amphibolite facies but the development of andalusite rather than sillimanite is indicative of a slightly lower grade of metamorphism (Guitard, 1970).

The assemblages of the retrogressive metamorphism (M_3) are characteristic of the greenschist facies. Prehnite, which occurs sporadically in the Gods Lake area, indicates an even lower grade of metamorphism was locally attained—the pumpellyite-prehnite-quartz facies of Winkler. Stilpnomelane, which may occur in this facies or in the lowest part of the greenschist facies, is indicative of intermediate to high pressure (Winkler, op. cit.). It is concluded that intermediate to high pressures were attained during M_1 and M_2 (slightly above those of Abukuma-type metamorphism). M_3 was characterized by (at least) intermediate pressure required for the development of stilpnomelane.

STRUCTURAL GEOLOGY

Volcanic rocks of the Hayes River Group form a south-facing monocline between Cinder Lake and southern Knee Lake. Oxford Lake Group strata in the area to the south are deformed in a series of major folds; north-facing sediments (10a) at the south margin of the section indicate a synclinorial structure for the Oxford Lake Group (Oxford House and Knee Lake areas, NTS 53L/14 and 53L/15).

Hayes River Group rocks at Gods Lake form several major folds with axial traces trending variously between north and southeast. North of Gods Lake, a sequence of mafic volcanics ($1b_2$) is overlain by northeast-facing metasedimentary rocks (3f) which outcrop sporadically along Gods River (Semmens River area, NTS 53N/4). South-facing feldspathic greywacke at Sturgeon Falls (on Gods River, at latitude 55°16') indicates the metasediments form a synclinal structure.

F_1 deformation is inferred to accompany the earliest (pre-Oxford Lake Group) M_1 metamorphic event (Table 14). The earliest, tight to isoclinal major folds in the Hayes River Group at Gods Lake are interpreted as a result of the F_1 event inferred from the metamorphic history but an F_2 age is also possible. An F_1 age is probable for the northwest-trending syncline at northern Elk Island where the major fold and the trend of the mafic volcanic flows (1b, 1c) are discordant to and truncated by the margins of the Elk Island pluton (7); the axial trace of the syncline is deformed by northwest-directed movements possibly related to the emplacement of the pluton. The structural trend of the Munro Lake greenstone belt was also apparently established prior to the Oxford Lake Group and the emplacement of the granodiorite pluton (7c) at Colen Lakes, which truncates the regional foliation (Munro Lake area, NTS 53L/11). The regional foliation is almost invariably parallel to the primary layering and axial-planar to the major folds at Gods Lake.

The Oxford Lake Group is deformed by major tight to isoclinal folds (F_2) associated with regional foliation and metamorphism (M_2). Earlier F_1 structures in the Hayes River Group at Gods Lake were probably tightened during F_2. At southern Knee Lake the F_2 folds are moderately to steeply plunging, with east-northeast to east-southeast trending axial traces. The regional foliation of the Oxford Lake Group is deformed by closed to tight F_3 folds in which axial planes and fold axes are inclined at moderate to steep angles (Plate 45); these folds are parallel or subparallel to the earlier F_2 structures (projections 3 and 10, Figs. 18 and 19). A weak axial-planar foliation is locally developed in F_3 fold-cores (Fig. 16 and Plates 11 and 51); associated linear structures (L_3) include widespread mineral lineation and attenuation of clasts, and local rodding, microcrenulation, and boudinage. The parallel plunges of F_2 and F_3 linear structures at southern Knee Lake are illustrated in projection 15 (Fig. 18) showing structural elements in subdomains KIa and KIb (Fig. 19).

F_4 comprises closed folds with subhorizontal to subvertical axes and roughly vertical axial planes normal to the F_3 folds. F_3 structural elements have been dispersed by F_4 (projections 1, 2, 6, 7, 8, 9 and 13). Structural analysis in the vicinity of northern Elk Island (structural subdomain GIIIa, Fig. 19) indicates F_3 axial planes are folded by a steeply plunging southeast-trending fold attributed to F_4 (projection 16, Fig. 18). Variations in the trend of the regional foliation are partly related to F_4 and partly to earlier deformation (syn- or pre-F_3). The influence of earlier deformation is indicated by analysis of the local structure at northern Gods Lake (domain GV, Fig. 19) where F_3 folds plunge consistently east to east-southeast, in spite of major variations in the trend of the regional foliation (projections 12 and 17, Figs. 18 and 20). The variations in foliation trend are attributed to F_3 or pre-F_3 deformation because post-F_3 warping would have resulted in dispersion of the F_3 minor folds.

There is little evidence for F_3 and F_4 in the Michikinabish Lake-Brown Lake gneiss complex (6), although rare refolded folds may be a result of the F_3 or F_4 events recognized in the supracrustal rocks (Table 7). The effects of D_3 in the gneiss complex are very similar to those of D_5 described below and these events may be equivalent.

The final event (D_5) consists of brittle deformation in conjugate fractures, minor faults, and rare *en echelon* dilation fractures (Plate 55); these are locally intruded by felsic veins or diabase dykes (12b). Shear zones parallel to the regional foliation and associated with retrogressive metamorphism (M_3) are also attributed to D_5. Shearing was locally intense, resulting in cataclasite at Magill Creek (Munro Lake area, NTS 53L/11) and mylonite at northern Elk Island (Gods Lake area, NTS 53L/9) where a prominent northwest-trending lineament is interpreted as a shear zone. Some shearing parallel to the regional foliation preceded F_3 and there is evidence of early concordant shearing in blastomylonite at Gods Lake Narrows (B. Marten, pers. comm.). The trend of D_5 fractures and associated dykes and veins ranges from normal to parallel to the regional foliation, but the majority are parallel or slightly discordant to the foliation—e.g. at the west end of southern Knee Lake (domain KI) the

Plate 55: *En echelon quartz veins filling fractures produced by late brittle deformation (D_5) in pyroclastic breccia (8e) at southern Knee Lake.*

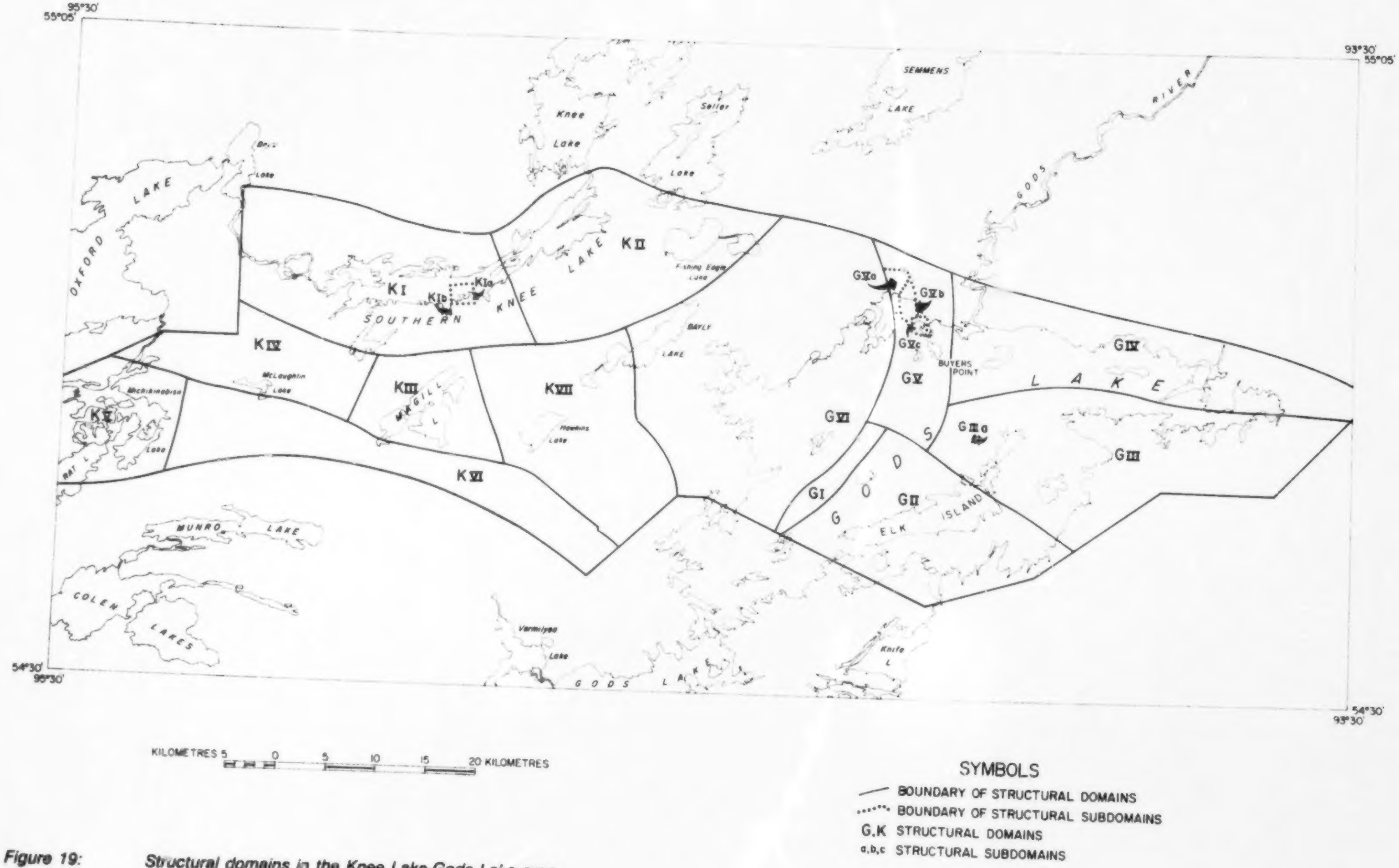

95°30'
55°05'
93°30'
55°05'
54°30'
95°30'
54°30'
93°30'
OXFORD LAKE
Knee Lake
Seller Lake
SEMMENS LAKE
GODS RIVER
Fishing Eagle Lake
BAYLY LAKE
KI
KIa
KIb
KII
KIII
KIV
KV
KVI
KVIII
SOUTHERN KNEE LAKE
McLaughlin Lake
Michikinabish Lake
RAT L
MCGILL L
Hawkins Lake
GIa
GVa
GVb
GVc
GI
GII
GIIa
GIII
GIV
GV
GVI
BUYERS POINT
GODS LAKE
ELK ISLAND
MUNRO LAKE
COLEN LAKES
Vermilyea Lake
Knife L
KILOMETRES 5 0 5 10 15 20 KILOMETRES
SYMBOLS
BOUNDARY OF STRUCTURAL DOMAINS
BOUNDARY OF STRUCTURAL SUBDOMAINS
G,K STRUCTURAL DOMAINS
a,b,c STRUCTURAL SUBDOMAINS

Figure 19: *Structural domains in the Knee Lake-Gods Lake area.*

trend is mainly west to west-southwest (projections 4 and 5, Fig. 18) and at Gods Lake, in the vicinity of Elk Island (domain GII) faults are mainly west-southwest and east-southeast (projection 11, Fig. 18). The trend of faults, dykes and veins in the Gods Lake area ranges from northwest to west-southwest, which corresponds to the variation in regional foliation in that area (projection 14, Fig. 18).

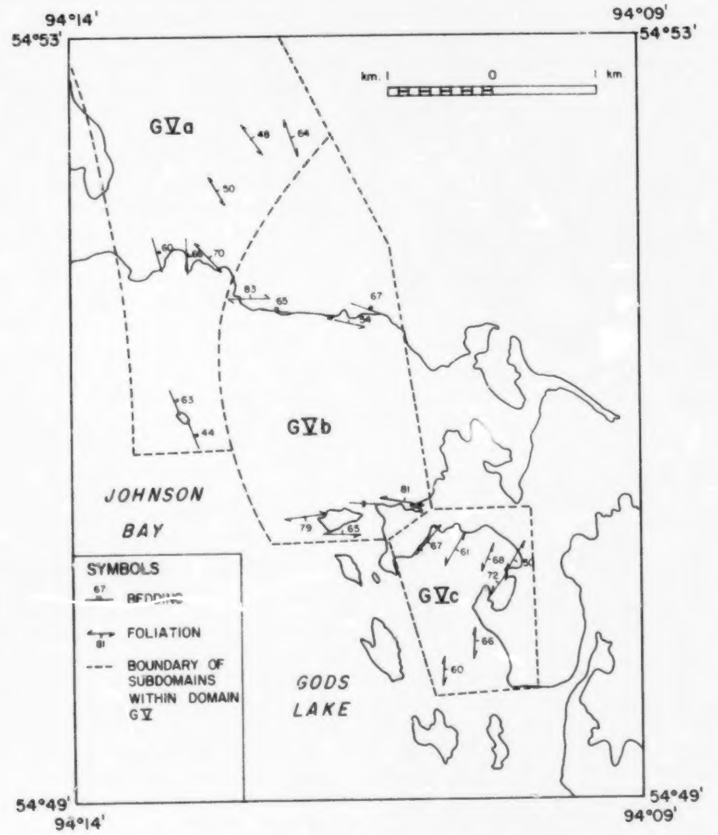

94°14'
54°53'
94°09'
54°53'
km. 1
0
1 km
GVa
GVb
GVc
JOHNSON
BAY
GODS
LAKE
SYMBOLS
BEDDING
FOLIATION
BOUNDARY OF SUBDOMAINS WITHIN DOMAIN GV
54°49'
94°14'
54°49'
94°09'

Figure 20: *Bedding and regional foliation in subdomains GVa, GVb and GVc, northern Gods Lake.*

REFERENCES

Baker, W.F.
1935: Geology of Gods Lake Gold Mines Limited; Transactions of the Canadian Institute of Mining and Metallurgy, v. 38, p. 155-162.

Barlow, R.B.
1973: Major and minor element geochemistry of the Archean volcanic rocks of the southern Knee Lake area, Manitoba; unpublished M.Sc. thesis, Michigan Technological University.

Barry, G.S.
1959: Geology of the Oxford House-Knee Lake area; Manitoba Mines Branch publication 58-3.
1960: Geology of the western Oxford Lake-Cargill Island area; Manitoba Mines Branch publication 59-2.
1961: Geology of the Gods Narrows area; Manitoba Mines Branch publication 60-1.
1962: Geology of the Munro Lake area; Manitoba Mines Branch publication 61-1.
1964: Geology of the Parker Lake area; Manitoba Mines Branch publication 62-1.

Bennett, G.
1975: A petrogenetic model for lamprophyres of the northeast Timagami area, Ontario; Geological Society of America and Geological Association of Canada, Annual Meeting Abstracts, v. 7, No. 6, p. 721.

Brooks, C., Ludden, J., Pigeon, Y. and Hubregtse, J.J.M.W.
1982: Volcanism of shoshonite to high-K andesite affinity in an Archean arc environment, Oxford Lake, Manitoba; Canadian Journal of Earth Sciences, v. 19, p. 55-67.

Burwash, R.A., Baadsgaard, H., and Peterman, Z.E.
1962: Precambrian K-Ar dates from the Western Canada Sedimentary Basin; Journal of Geophysical Research, v. 67, p. 1617-1625.

Černý, P.
1983: Preliminary strategic minerals evaluation and geochronological project: Final Report — Part I; Manitoba Mineral Resources Division, unpublished report.

Chastko, L.C.
1978: Report for mineral dispositions C.B. 7385 and 7386, Knee Lake area, Manitoba; Manitoba Mineral Resources Division, cancelled assessment data.

Clark, G.S. and Cheung, S.P.
1977: Rubidium-strontium whole-rock ages from the Oxford Lake-Knee Lake greenstone belt, northeastern Manitoba; Annual Report 1977, Centre for Precambrian Studies, University of Manitoba, p. 106-121.

Dix, W.F.
1951: Geology of the Gods Lake area; Manitoba Mines Branch, Preliminary Report 47-4.

Downie, D.L.
1936: Stull Lake sheet; Geological Survey of Canada Maps 451A and 452A.

Elbers, F.J.
(in prep.): Geology of the Knee Lake-Munro Lake area and Goose Lake area; Manitoba Energy and Mines, Geological Report GR83-1C.

Fahrig, W.F., Gaucher, E.H., and Larochelle, A.
1965: Paleomagnetism of diabase dykes of the Canadian Shield; Canadian Journal of Earth Sciences, v. 2, p. 278-298.

Fisher, R.V.
1964: Maximum size, median diameter, and sorting of tephra; Journal of Geophysical Research, v. 69, p. 341-355.
1966: Rocks composed of volcanic fragments and their classification; Earth-Science Reviews, v. 1, p. 287-298.

Fox, J.S.
1976: Rapid pyroclastic mapping in base metal exploration; Saskatchewan Research Council Geological Division, Circular No. 8.

Furnes, H.
1973: Variolitic structure in Ordovician pillow lava and its possible significance as an environmental indicator; Geology, v. 1, p. 27-30.

Gates, R.M.
1953: Petrogenic significance of perthite; **in**: R.C. Emmons (ed.), Selected petrogenic relationships of plagioclase; Geological Society of America, Memoir 52, p. 55-70.

Gélinas, L., Brooks, C. and Trzcienski, Jr. W.E.
1976: Archean variolites — quenched immiscible liquids; Canadian Journal of Earch Sciences, v. 13, p. 210-230.

Gélinas, L., Lajoie, J., Brooks, C., Cloutier, M. and Valiquette, G.
1975: Ultramafic tuff: another Archean-only phenomenon?; Geological Society of America and Geological Association of Canada, Annual Meeting Abstracts, v. 7, p. 761.

Godard, J.D.
1963: Geology of the Island Lake-York Lake area; Manitoba Mines Branch, Publication 59-3.

Goodwin, A.M.
1962: Structure, stratigraphy and origin of iron formations, Michipicoten area, Algoma District, Ontario, Canada; Geological Society of America Bulletin, v. 73, p. 561-586.

Green, N.L.
1973: The volcanic stratigraphy and petrochemistry of the Gods Lake Subgroup, Knee Lake, Manitoba; unpublished M.Sc. thesis, University of Manitoba, 132 p.
1975: Archean glomeroporphyritic basalts; Canadian Journal of Earth Sciences, v. 12, p. 1770-1784.

Gross, G.A.
1963: Distribution of iron deposits, Sachigo River area. Geological Survey of Canada Map 20-1963.
1965: Geology of iron deposits of Canada: Vol. 1 General Geology and Evaluation of Iron Deposits; Geological Survey of Canada, Economic Geology Report No. 22.

Guitard, G.
1970: Le métamorphisme Hercynien mésozonal et les gneiss oeillés du massif du Canigou (Pyrénées orientales); Bureau de Recherches Géologiques et Minières, France, Mémoire No. 63.

Hubregtse, J.J.M.W.
1976: Volcanism in the western Superior Province in Manitoba; In: B.F. Windley (ed.), Early History of the Earth; Wiley, New York, p. 279-287.
1978: Chemistry of cyclic subalkaline and younger shoshonitic volcanism in the Knee Lake-Oxford Lake Greenstone Belt, Northeastern Manitoba; Manitoba Mineral Resources Division, Geological Paper 78/2, p. 1-18.
1985: Geology of the Oxford Lake-Carrot River area; Manitoba Energy and Mines, Geological Report GR83-1A.

Krogh, T.E., Ermanovics, I.F. and Davis, G.L.
1974: Two episodes of metamorphism and deformation in Archean rocks of the Canadian Shield; Carnegie Institution Washington Yearbook 73, pp. 573-575.

Leech, G.B., Lowdon, J.A., Stockwell, C.H. and Wanless, R.K.
1963: Age determinations and geological studies (including isotopic ages — Report 4); Geological Survey of Canada, Paper 63-17, 140 p.

Mackenzie, D.W. and Chappell, B.W.
1972: Shoshonitic and calc-alkaline lavas from the Highlands of Papua New Guinea; Contributions to Mineralogy and Petrology, v. 35, p. 50-62.

Marmo, V.
1971: Granite petrology and the granite problem — Developments in Petrology 2; Elsevier, Amsterdam, 244 p.

Marten, B.E.
(in prep.): Geology of the Gods-Knife-Webber Lakes area; Manitoba Energy and Mines, Geological Report GR83-1D.

Mehnert, K.R.
1968: Migmatites and the origin of granitic rocks; Elsevier, Amsterdam, 393 p.

Middlemost, E.A.K.
1973: A simple classification of volcanic rocks; Bulletin Volcanologique, v. 36, p. 382-397.

Minakami, T.
1942: On the distribution of volcanic ejecta: Part I. The distributions of volcanic bombs ejected by the recent explosions of Asama. Part II. The distribution of Mt. Asama pumice in 1783; Bulletin of the Earthquake Research Institute, Tokyo Imperial University, v. XX, p. 65-106.

Moore, J.M., Hart, S.R., Barnett, C.C. and Hurley, P.M.
1960: Potassium-argon ages in northern Manitoba; Geological Society of America Bulletin, v. 71, p. 225-230.

Pearce, T.H.
1974: Quench plagioclase from some Archean basalts; Canadian Journal of Earth Sciences, v. 11, p. 715-719.

Pettijohn, F.J.
1957: Sedimentary Rocks; Harper Bros.; 718 p.

Pitcher, W.S. and Berger, A.R.
1972: The geology of Donegal: a study of granite emplacement and unroofing; Wiley-Interscience, New York, 435 p.

Potter, R.R.
1962: Gods River map-area, Manitoba; Geological Survey of Canada, Paper 62-8.

Quinn, H.A.
1960: Geology of the Island Lake area, Manitoba-Ontario; Geological Survey of Canada Map 26-1960.

Quinn, H.A. and Currie, K.L.
1961: Geology of the Oxford House area, Manitoba; Geological Survey of Canada Map 21-1961, with marginal notes.

Reinhardt, E.W.
1972: Occurrences of exotic breccias in the Petitot Islands (85H/10) and Wilson Island (85H/15) map-areas, east arm of Great Slave Lake, District of Mackenzie; Geological Survey of Canada, Paper 72-25.

Reynolds, D.L.
1954: Fluidization as a geological process and its bearing on the problem of intrusive granites; American Journal of Science, v. 252, p. 577-614.

Rousell, D.H.
1965: Geology of the Cross Lake area; Manitoba Mines Branch, Publication 62-4.

Scoates, R.F.J. and Macek, J.J.
1978: Molson dyke swarm; Manitoba Mineral Resources Division, Geological Paper 78-1, 53 p.

Seguin, M.K. and Laurent, R.
1975: Petrological features and magnetic properties of pillow lavas from the Thetford Mines Ophiolite (Quebec); Canadian Journal of Earth Sciences, v. 12, p. 1406-1420.

Smith, D.R., McNutt, R.H. and Clifford, P.M.
1973: Nature and origin of salic pyroclastic rocks at Kakagi Lake, northwestern Ontario; Canadian Journal of Earth Sciences, v. 10, p. 538-550.

Snyder, G.L. and Fraser, G.D.
1963: Pillowed lavas, I: Intrusive layered lava pods and pillowed lavas, Unalaska Island, Alaska and Pillowed lavas, II: a review of selected recent literature; United States Geological Survey, Professional Paper 454-B, C, p. B1-B23, C1-C7.

Sopuck, V.
1971: Report of geological investigations on Reservation 105 Wilsie-Red Cross area; Barringer Research Ltd.; Manitoba Mineral Resources Division, cancelled assessment data.

Southard, G.G.
1977: Exploration history, compilation and review including exploration data from cancelled assessment files for the Gods, Knee and Oxford Lakes areas, Manitoba; Manitoba Mineral Resources Division, Open File Report 77/5.

Springer, G.D.
1947: Geology of the Knee Lake area; Manitoba Mines Branch Preliminary Report 46-1.

Spry, A.
1969: Metamorphic textures; Pergamon, New York, 350 p.

Spurr, J.E.
1900: Classification of igneous rocks according to composition; American Geologist, v. XXV, p. 229-230.

Streckeisen, A.L.
1967: Classification and nomenclature of igneous rocks. Final report of an inquiry; Neues Jahrbuch fuer Mineralogie, Abhandlungen, 107: p. 144-240.

Taylor, F.C. and Baer, A.J.
1973: Piemontite-bearing explosion breccia in Archean rocks, Labrador, Newfoundland; Canadian Journal of Earth Sciences, v. 10, p. 1397.

Thorarinsson, S.
1954: The tephra-fall from Hekla on March 29, 1947: The eruption of Hekla, 1947-1948; Museum of Natural History, Society of Science, Islandica, Reykjavik, 68 p.

Turner, F.J. and Verhoogen, J.
1960: Igneous and metamorphic petrology; McGraw-Hill, New York, 694 p.

Vance, J.A.
1969: On synneusis; Contributions to Mineralogy and Petrology, v. 27, p. 7-29.

Walker, G.P.L.
1971: Grain size characteristics of pyroclastic deposits; Journal of Geology, v. 79, p. 696-714.

Walker, R.G.
1967: Turbidite sedimentary structures and their relationship to proximal and distal depositional environments; Journal of Sedimentary Petrology, v. 37, p. 25-43.

Wanless, R.K., Stevens, R.D., Lachance, G.R. and Rimsaite, J.Y.H.
1966: Age determinations and geological studies: K-Ar isotopic ages, Report 6; Geological Survey of Canada, Paper 65-17, 101 p.

Williams, H., Turner, F.J. and Gilbert, C.M.
1958: Petrography: An introduction to the study of rocks in thin sections; Freeman, San Francisco, 406 p.

Winkler, H.G.F.,
1967: Petrogenesis of metamorphic rocks, 2nd edition; Springer-Verlag, Berlin, 237 p.

BIBLIOGRAPHY OF OTHER PUBLICATIONS RELATING TO THE GREENSTONE PROJECT

Bannatyne, B.B.
1973: Pegmatite project; **in**: Summary of Geological Field Work 1973; Manitoba Mines Branch, Geological Paper 2/73, p. 29-33.

Campbell, F.H.A., Elbers, F.J. and Gilbert, H.P.
1972: The stratigraphy of the Hayes River Group in Manitoba — a preliminary report; Manitoba Mines Branch, Geological Paper 2/72, 33 p.

Chastko, L.C. and Gibson, J.C.
1977: Precious metals exploration; **in**: Report of Field Activities 1976, Manitoba Mineral Resources Division, Mineral Evaluation and Administration and Exploration Operations Branches, p. 74-78.

Cheung, S.P.
1978: Rubidium-strontium whole-rock ages from the Oxford Lake-Knee Lake Greenstone Belt, northern Manitoba; unpublished M.Sc. thesis, University of Manitoba, 41 p.

Cutforth, C. and Petak, H.W.
1977: Webber-Sharpe Lakes and Edmund-Margaret Lakes Greenstone Belts; **in**: Report of Field Activities 1977, Manitoba Mineral Resources Division, p. 158-161.

Elbers, F.J.
1976: Calc-alkaline plutonism, volcanism and related hydrothermal mineralization in the Superior Province of northeastern Manitoba; Canadian Institute of Mining and Metallurgy Bulletin, v. 69, p. 1-18.

Elbers, F.J. and Gilbert, H.P.
1972: Greenstones project; **in**: Summary of Geological Field Work 1972, Manitoba Mines Branch, Geological Paper 3/72, p. 32-44.

Elbers, F.J., Hubregtse, J.J.M.W. and Gilbert, H.P.
1973: Greenstones project; **in**: Summary of Geological Field Work 1973, Manitoba Mines Branch, Geological Paper 3/73, p. 12-27.

Evans, D.S.
1977: Base metal exploration; **in**: Report of Field Activities 1977, Manitoba Mineral Resources Division, p. 157.

Gale, G.H., Baldwin, D.A., Solkoski, L., Ostry, G. and Fedikow, M.
1977: Evaluation of massive sulphide environments; **in**: Report of Field Activities 1977, Manitoba Mineral Resources Division, p. 109-112.

Gale, G.H., Koo, J., Solkoski, L. and Southard, G.G.
1976: Evaluation of massive sulphide environments; Manitoba Mineral Resources Division, Open File Report 77/1, p. 34-62.

Giesbrecht, K.O.
1972: The deformational history of a portion of the Oxford Lake subgroup, Gods Lake Narrows, Manitoba; unpublished M.Sc. thesis, University of Manitoba, 66 p.

Haskins, R.A. and Evans, D.S.
1977: Cat Eye Bay; **in**: Report of Field Activities 1976, Manitoba Mineral Resources Division, Mineral Evaluation and Administration and Exploration Operations Branches, p. 66-68.

Haskins, R.A. and Stephenson, J.F.
1974: Geology and mineralization of western Oxford Lake and Carrot River; **in**: Summary of Geological Field Work 1974, Manitoba Mineral Resources Division, Geological Paper 2/74, p. 35-46.

Humiski, R.N.
1974: The deformation history of the south-central portion of the Munro Lake greenstone belt, northern Manitoba; unpublished M.Sc. thesis, University of Manitoba, 78 p.

Macek, J.J. and Trueman, D.L.
1972: Beaver Hill Lake mafic complex (53L-7NW); Manitoba Mines Branch, Preliminary Map 1972A-1.

McGregor, C.R. and Petak, H.W.
1977: Reekie Lake; **in**: Report of Field Activities 1976, Manitoba Mineral Resources Division, Mineral Evaluation and Administration and Exploration Operations Branches, p. 62-63.

Scoates, R.F.J.
1971: Ultramafic rocks projects; **in**: Summary of Geological Field Work 1971, Manitoba Mines Branch, Geological Paper 6/71, p. 51-55.

Scoates, R.F.J., Elbers, F.J., Campbell, F.H.A. and Gilbert, H.P.
1971: Greenstones project; **in**: Summary of Geological Field Work 1971, Manitoba Mines Branch, Geological Paper 6/71, p. 46-48.

Scoates, R.F.J., Trueman, D.L. and Macek, J.J.
1972: Ultramafic rocks project; **in**: Summary of Geological Field Work 1972, Manitoba Mines Branch, Geological Paper 3/72, p. 45-48.

Soonawala, N.
1978: Regional geophysical surveys; **in**: Report of Field Activities 1978, Manitoba Mineral Resources Division, p. 70-82.

Stephenson, J.F.
1977: Uranium reconnaissance program; **in**: Report of Field Activities, 1977, Manitoba Mineral Resources Division, p. 168-170.

Theyer, P.
1977: Evaluation of nickel environments; **in**: Report of Field Activities 1977, Manitoba Mineral Resources Division, p. 117-121.

Appendix A: Chemical analyses of felsic volcanic rocks ($2a_1$) at southern Knee Lake.

Sample Number	391-3	399-1	431-2	1587-1	1588-3
Composition	RHYOLITE	DACITE	RHYOLITE	DACITE	DACITE
Phase (as defined in Table 4)	I	I	I	I	II
SiO_2	73.85	69.45	70.35	68.65	67.85
Al_2O_3	12.75	14.8	15.0	17.15	14.0
Fe_2O_3	0.45	0.68	0.57	0.51	2.06
FeO	0.78	1.27	1.65	1.45	2.19
CaO	2.42	1.75	2.89	2.33	2.76
MgO	0.51	1.30	0.70	1.07	1.44
Na_2O	3.45	5.52	4.64	4.00	1.90
K_2O	2.35	1.80	1.11	2.15	3.00
TiO_2	0.60	0.33	0.49	0.70	0.53
P_2O_5	0.20	0.16	0.13	0.13	0.16
MnO	0.05	0.03	0.05	0.07	0.08
H_2O	0.70	1.02	1.35	1.48	1.75
CO_2	1.50	2.30	0.73	0.60	1.75

Appendix B: Chemical analyses of rocks of the lower Oxford Lake Group volcanic complex (8) at southern Knee Lake and the diabase sill south of Michikanes Lake

	FIELD OCCURRENCE	MASSIVE FLOW OR SILL	DYKE	PILLOWED PORPHYRITIC FLOW	MASSIVE PORPHYRITIC FLOWS					CLASTS IN PYROCLASTIC BRECCIA										TUFF			DIABASE DYKE	DIABASE SILL
	SAMPLE NUMBER	430-1	1650-2	1504-1	1548-1	5023-1	5213-1	1533-5	1552-1	1537-1	5016-2	1487-2	5105-1	326-3	1515-1	5205-1	4246-1	365-2	5319-3	326-9	5213-2	5287-1	5025-7	1675-1
	UNIT NUMBER	$8b_1$	8b	$8b_2$	$8c_1$	$8c_1$	$8c_1$	$8d_1$	$8d_1$	8e	8e	8e	8e	8e	8e	8e	8e	8e	8e	8h	8h	8h	8i	8i
OXIDE (wt. per cent)	COMPOSITION	ABSAROKITE	LATITE	SHOSHONITE	ANDESITE			DACITE		RHYOLITE		DACITE		ANDESITE			SHOSHONITE	BASALT		ABSAROKITE	BASALT		ANDESITE	
SiO_2		48.7	58.70	56.55	59.85	57.05	56.5	63.1	62.85	71.05	72.55	64.75	68.10	60.75	54.15	60.10	55.6	50.25	53.15	47.5	47.25	46.5	54.05	54.15
Al_2O_3		17.6	15.35	20.6	14.55	14.70	16.45	15.8	15.3	12.45	15.35	15.0	14.20	14.3	14.0	15.80	15.6	9.05	13.9	12.25	9.75	8.45	15.30	15.2
Fe_2O_3		2.77	1.32	1.53	2.58	1.59	2.29	0.75	2.87	0.54	0.57	1.81	0.98	0.92	2.16	1.87	3.29	2.25	3.62	2.21	3.27	3.56	3.02	0.92
FeO		9.25	5.17	4.58	3.29	4.41	3.33	3.85	2.52	2.36	0.59	2.37	2.57	3.88	5.43	4.03	3.94	7.74	7.42	7.98	6.56	6.54	4.81	7.12
CaO		4.28	4.81	4.34	6.02	5.38	3.35	2.78	6.43	5.20	2.72	5.20	4.18	4.58	10.18	5.52	7.65	9.44	5.36	4.78	8.15	11.00	8.10	9.56
MgO		4.55	5.18	1.45	6.68	5.02	5.70	3.40	3.82	2.12	0.40	2.70	2.45	6.45	7.25	3.55	3.93	14.25	6.00	13.11	15.7	17.0	6.92	8.75
Na_2O		4.21	3.70	3.92	3.52	4.68	7.4	6.84	4.11	2.61	6.95	4.24	4.70	7.20	3.82	6.40	4.42	3.10	6.55	3.00	1.75	1.39	3.00	2.32
K_2O		2.78	3.12	3.57	1.90	0.94	1.60	1.60	1.58	1.35	0.36	1.26	1.45	0.39	0.38	1.38	2.55	0.29	0.36	3.83	1.74	1.70	1.12	0.30
TiO_2		0.88	0.57	0.76	0.49	0.50	0.55	0.47	0.44	0.31	0.38	0.42	0.42	0.39	0.68	0.55	0.65	0.68	1.19	0.96	0.57	0.78	0.56	0.67
P_2O_5		0.18	0.38	0.43	0.17	0.13	0.20	0.18	0.06	0.12	0.09	0.22	0.09	0.13	0.40	0.12	0.26	0.05	0.12	0.86	0.31	0.29	0.16	0.20
MnO		0.18	0.12	0.09	0.11	0.12	0.08	0.08	0.09	0.05	0.04	0.08	0.07	0.13	0.14	0.19	0.12	0.19	0.12	0.18	0.17	0.17	0.11	0.15
H_2O		2.57	1.41	0.89	1.20	2.56	1.32	0.84	1.00	0.82	0.22	0.79	0.55	0.85	1.20	0.85	0.92	2.47	1.05	2.92	3.86	2.76	2.18	1.02
CO_2		1.15	0.48	0.40	0.35	2.82	1.17	0.50	0.42	1.50	0.25	0.35	0.62	0.35	0.77	0.12	0.45	0.15	0.07	0.80	0.36	0.50	0.64	0.07

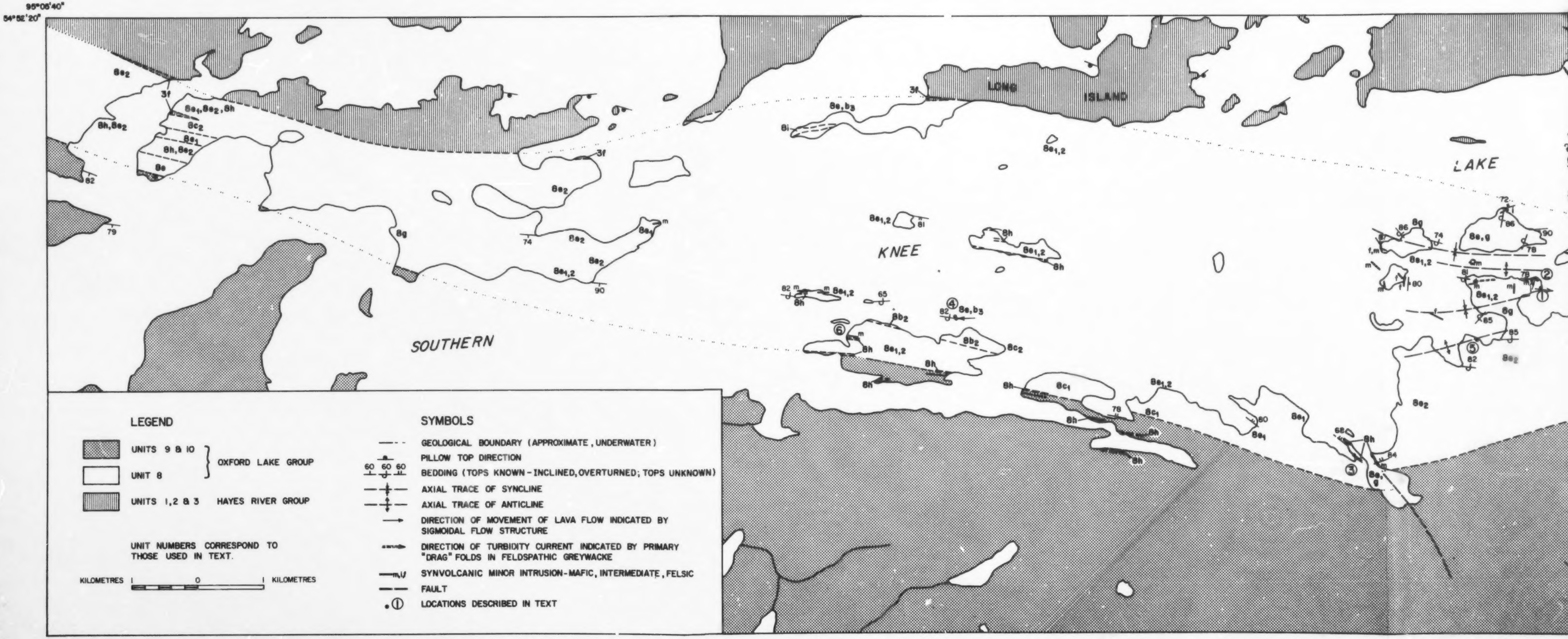
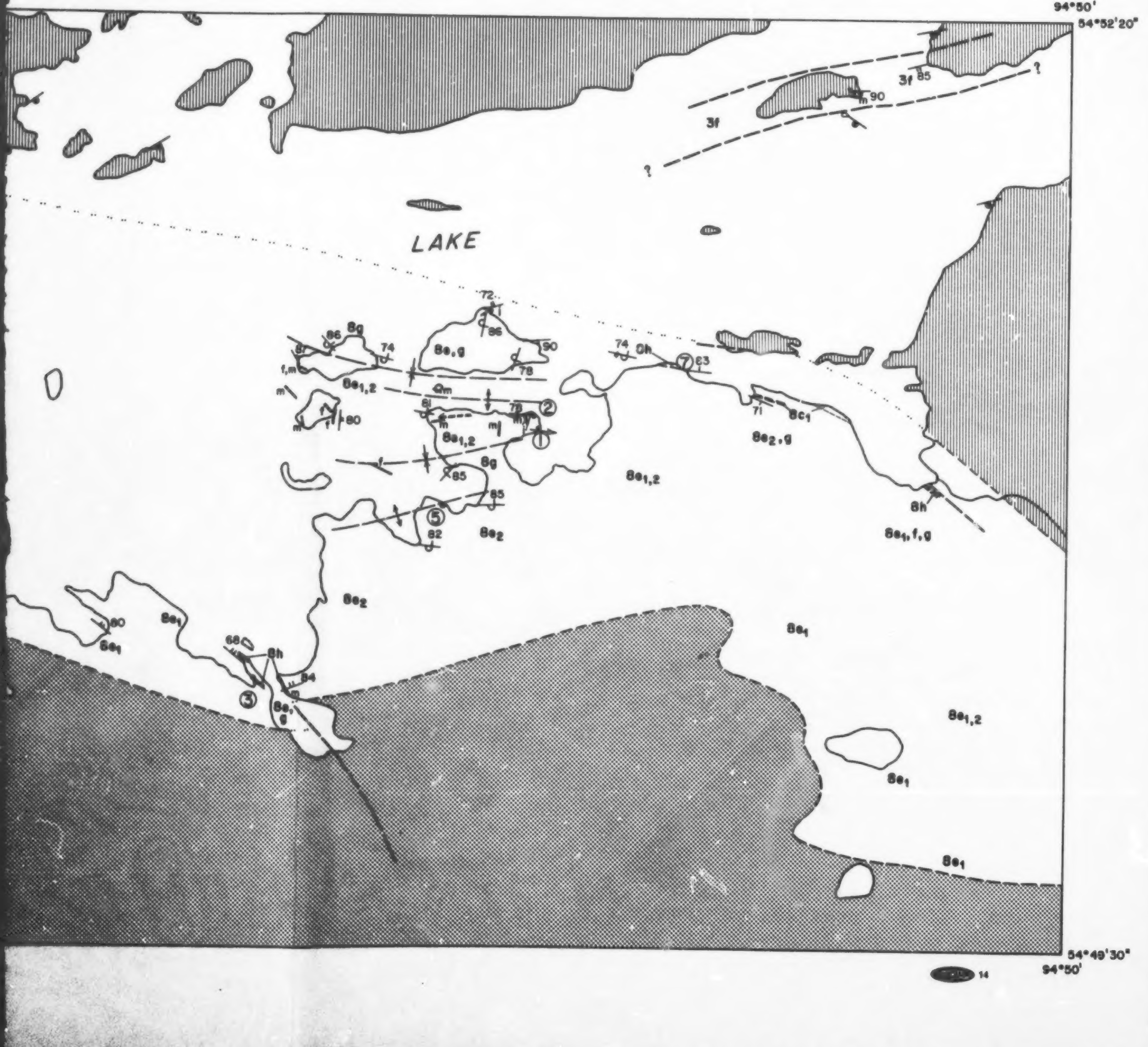

95°05'40"
54°52'20"
LONG ISLAND
KNEE
LAKE
SOUTHERN
LEGEND
UNITS 9 & 10
UNIT 8
OXFORD LAKE GROUP
UNITS 1,2 & 3
HAYES RIVER GROUP
UNIT NUMBERS CORRESPOND TO THOSE USED IN TEXT.
KILOMETRES 1 0 1 KILOMETRES
SYMBOLS
GEOLOGICAL BOUNDARY (APPROXIMATE, UNDERWATER)
PILLOW TOP DIRECTION
BEDDING (TOPS KNOWN - INCLINED, OVERTURNED; TOPS UNKNOWN)
AXIAL TRACE OF SYNCLINE
AXIAL TRACE OF ANTICLINE
DIRECTION OF MOVEMENT OF LAVA FLOW INDICATED BY SIGMOIDAL FLOW STRUCTURE
DIRECTION OF TURBIDITY CURRENT INDICATED BY PRIMARY "DRAG" FOLDS IN FELDSPATHIC GREYWACKE
SYNVOLCANIC MINOR INTRUSION - MAFIC, INTERMEDIATE, FELSIC
FAULT
LOCATIONS DESCRIBED IN TEXT
① ② ③ ④ ⑤ ⑥

Figure 10: Minor structures and distribution of lithologies within the lower Oxford Lake Group volcanic complex (8) at southern Knee Lake.


94°50'
54°52'20"
LAKE
3f
3f
85
90
?
?
8g
86
87
74
72
86
8e,g
90
78
f,m
8e1,2
Qm
m
80
8l
m
m
73
2
1
8e1,2
f
8g
85
85
5
82
8e2
74
Dh
7
63
71
8c1
8e2,g
8e1,2
8h
8e1,f,g
8e2
80
8e1
8e1
68
8h
84
3
8e1
g
8e1
8e1,2
8e1
8e1
54°49'30"
94°50'
14

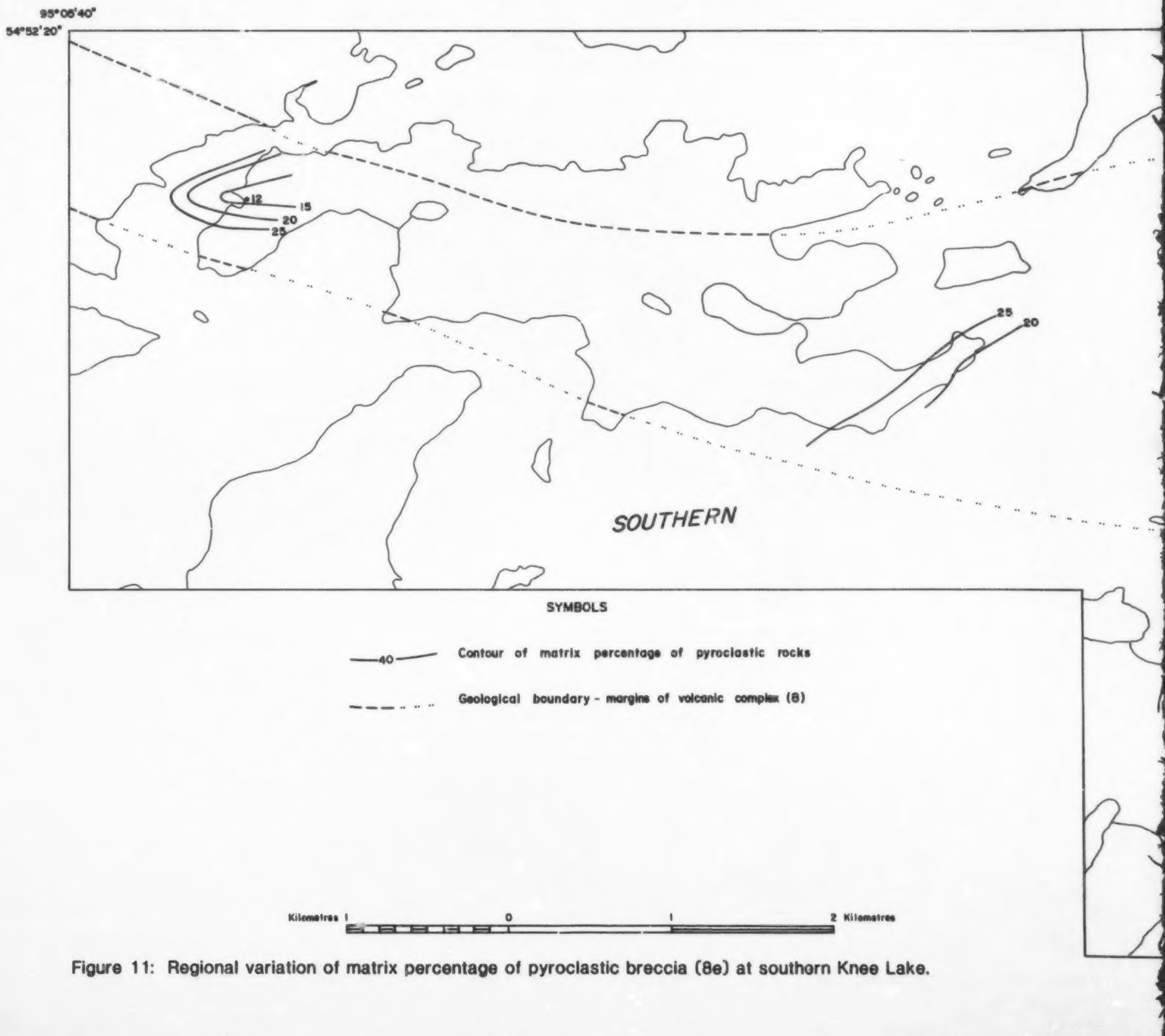
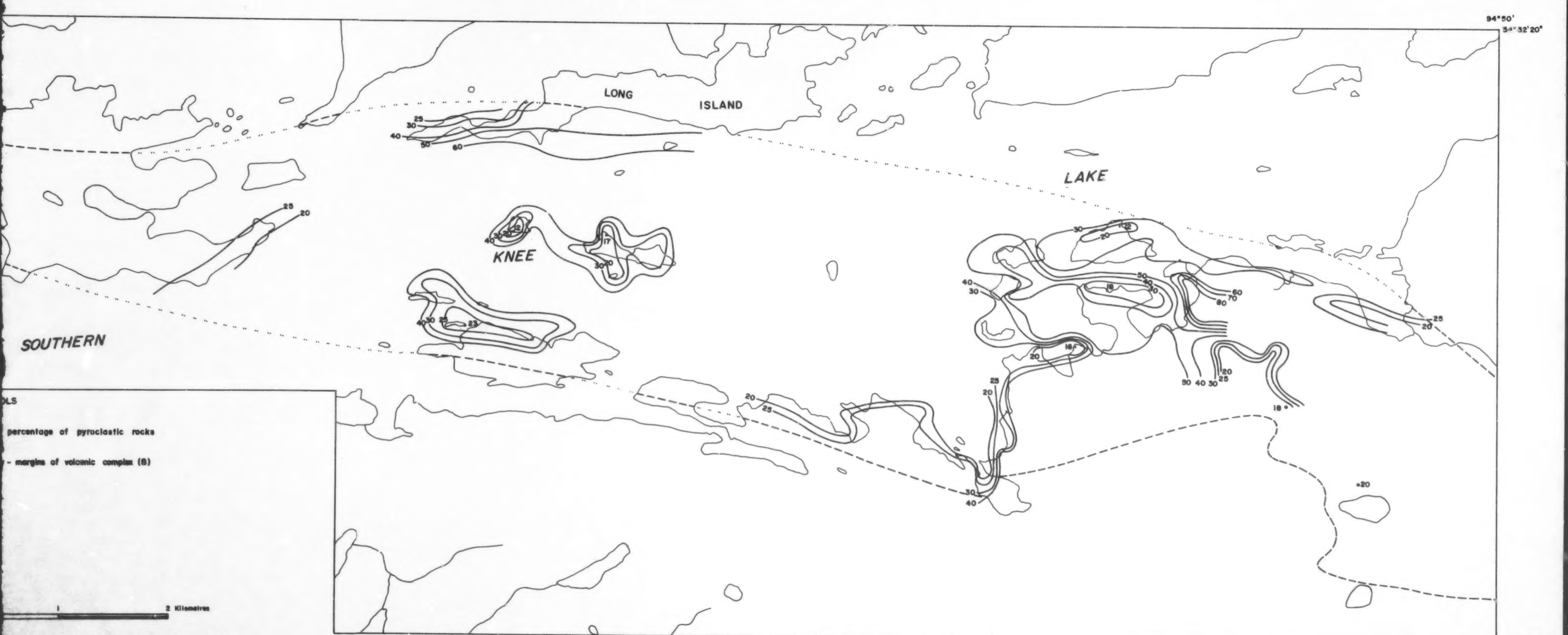

95°06'40"
54°52'20"
12
15
20
25
25
20
SOUTHERN
SYMBOLS
40
Contour of matrix percentage of pyroclastic rocks
Geological boundary - margins of volcanic complex (8)
Kilometres 1
0
1
2 Kilometres

Figure 11: Regional variation of matrix percentage of pyroclastic breccia (8e) at southern Knee Lake.


94°50'
54°32'20"
LONG ISLAND
LAKE
KNEE
SOUTHERN
OLS
percentage of pyroclastic rocks
- margins of volcanic complex (8)
1
2 Kilometres
54°49'30"
94°50'

stic breccia (8e) at southern Knee Lake.

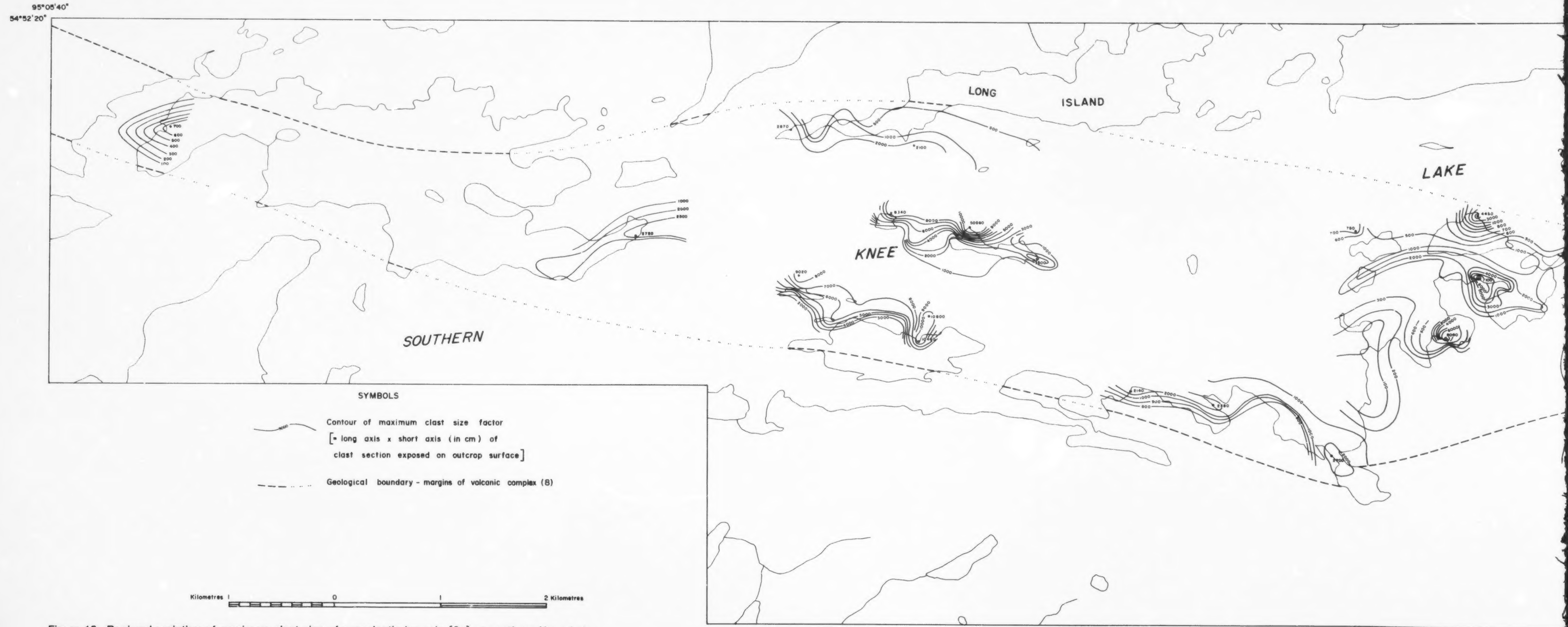
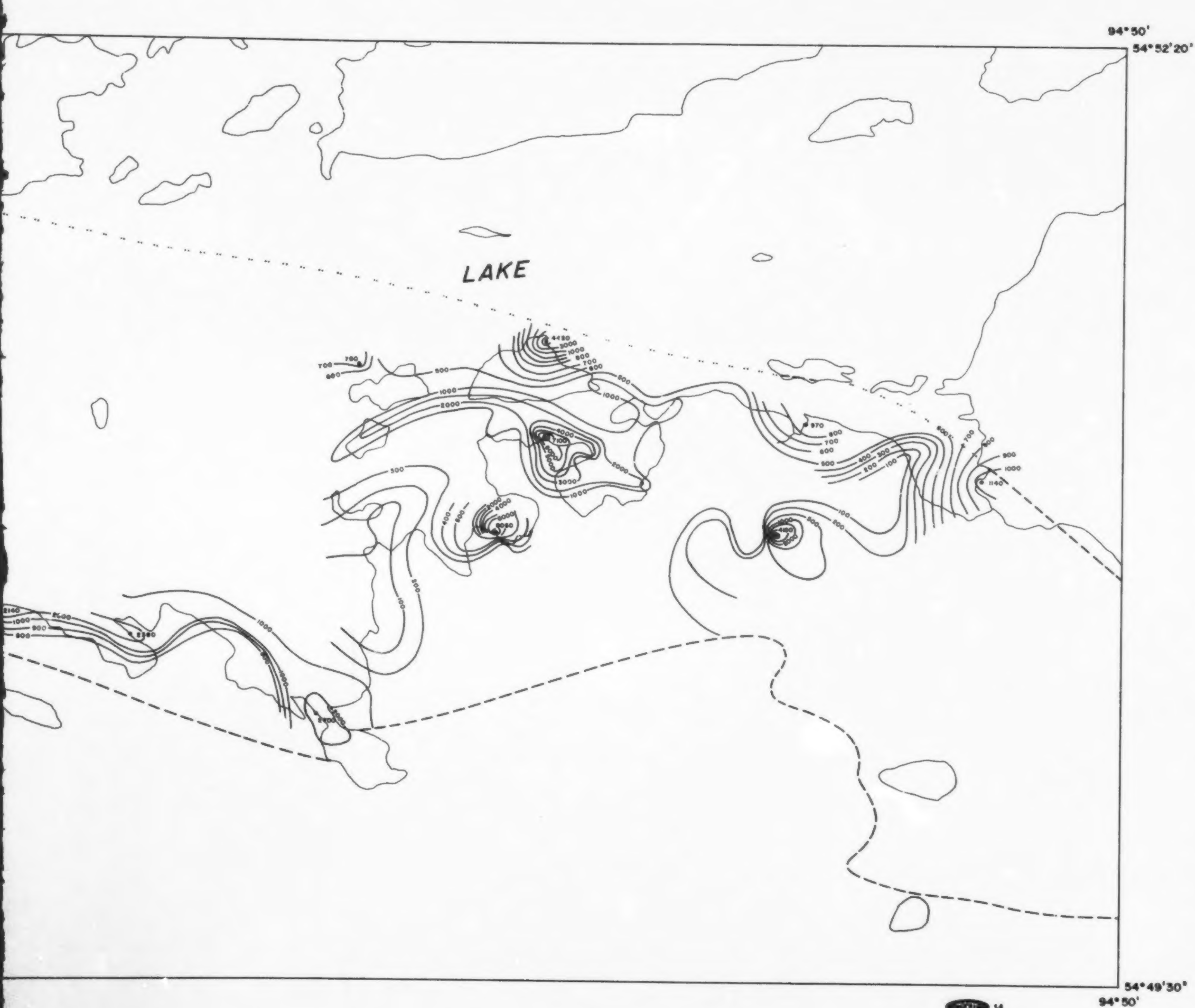

95°05'40"
54°52'20"
LONG
ISLAND
LAKE
KNEE
SOUTHERN
SYMBOLS
Contour of maximum clast size factor
[= long axis x short axis (in cm) of
clast section exposed on outcrop surface]
Geological boundary - margins of volcanic complex (8)
Kilometres 1
0
1
2 Kilometres

Figure 12: Regional variation of maximum clast size of pyroclastic breccia (8e) at southern Knee Lake.


94°50'
54°52'20"
LAKE
4430
3000
1000
800
700
600
790
700
600
500
1000
2000
4000
7100
3000
1000
2000
300
400
600
8080
200
100
970
800
700
600
500
400
300
200
100
1000
900
1140
4180
2000
2160
1000
900
600
2380
2400
54°49'30"
94°50'

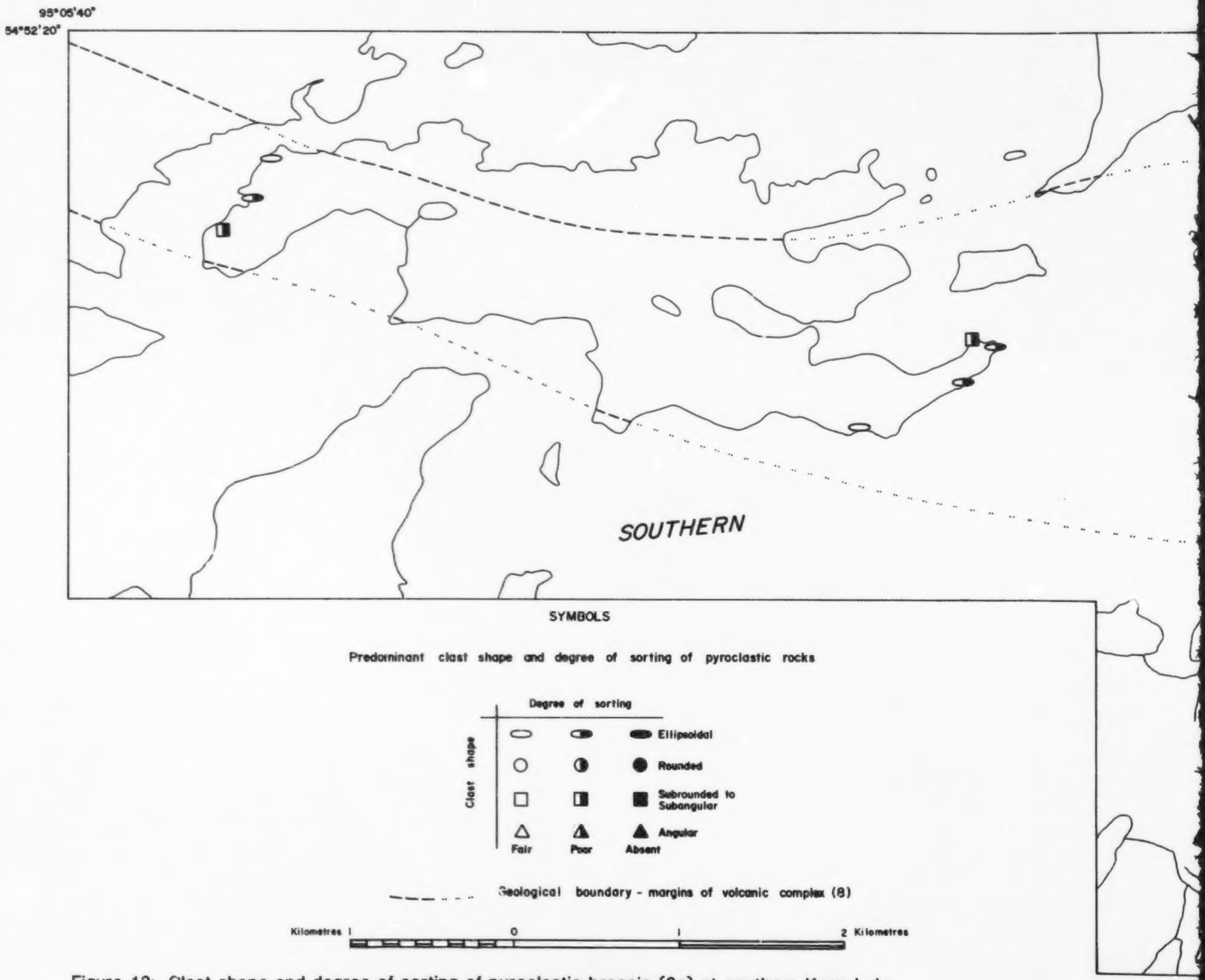
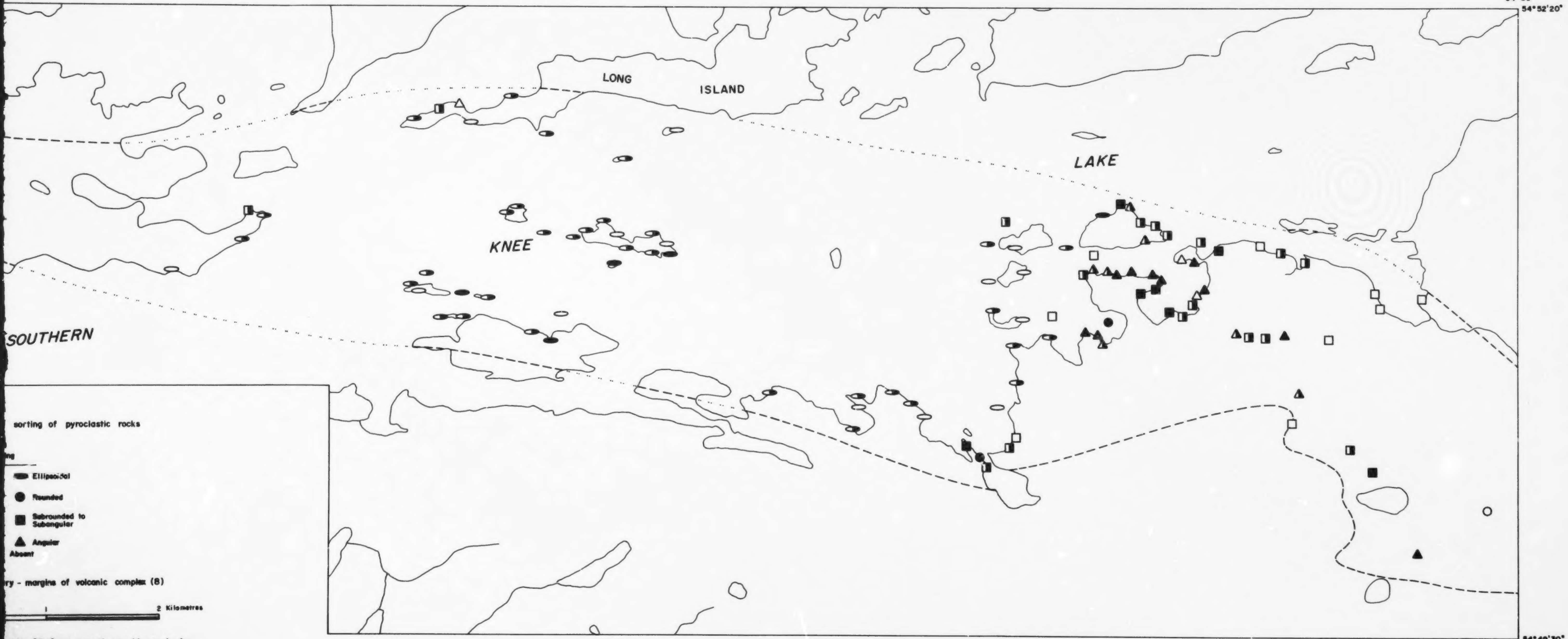
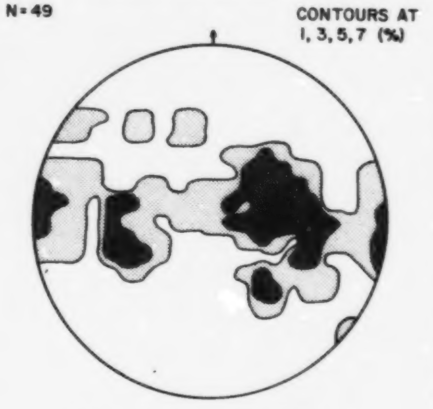

95°05'40"
54°52'20"
SOUTHERN
SYMBOLS
Predominant clast shape and degree of sorting of pyroclastic rocks
Degree of sorting
Clast shape
Ellipsoidal
Rounded
Subrounded to Subangular
Angular
Fair
Poor
Absent
Geological boundary - margins of volcanic complex (8)
Kilometres 1
0
1
2 Kilometres

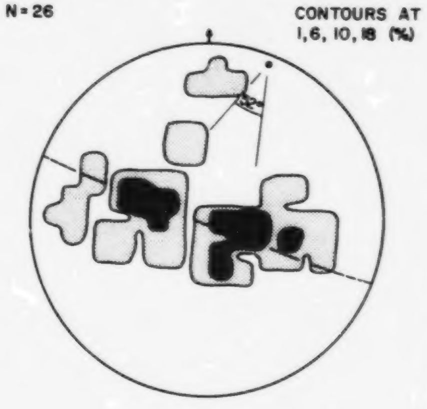
Figure 13: Clast shape and degree of sorting of pyroclastic breccia (8e) at southern Knee Lake.


94°50'
54°52'20"
LONG ISLAND
LAKE
KNEE
SOUTHERN
sorting of pyroclastic rocks
ng
Ellipsoidal
Rounded
Subrounded to Subangular
Angular
Absent
ry - margins of volcanic complex (8)
1
2 Kilometres
54°49'30"
94°50'

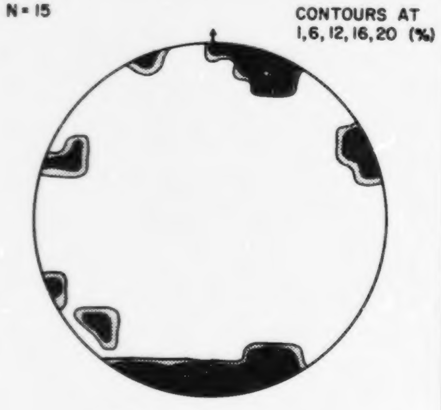
ccia (8e) at southern Knee Lake.


N=49
CONTOURS AT
1, 3, 5, 7 (%)

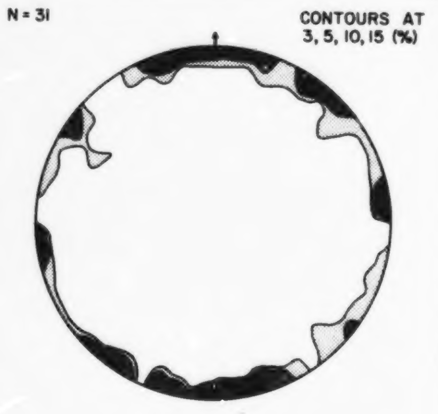
KI: F_3 LINEAR STRUCTURES 1


N=26
CONTOURS AT
1, 6, 10, 18 (%)
52°

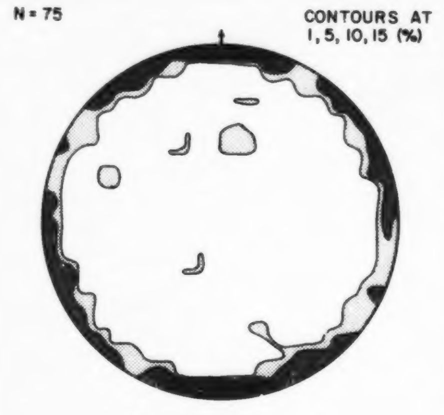
KI: F_3 FOLD AXES 2


N=15
CONTOURS AT
1, 6, 12, 16, 20 (%)

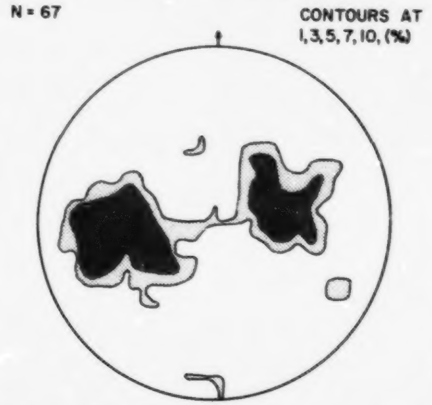
KI: F_3 AXIAL PLANES 3


N=31
CONTOURS AT
3, 5, 10, 15 (%)

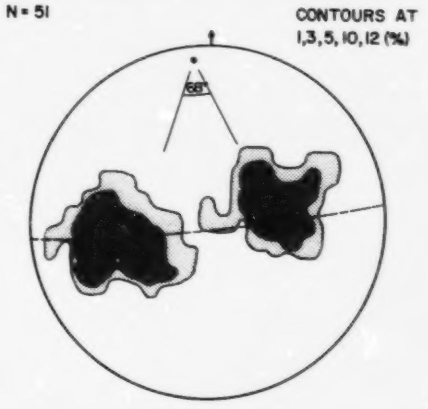
KI: FAULTS 4


N=75
CONTOURS AT
1, 5, 10, 15 (%)

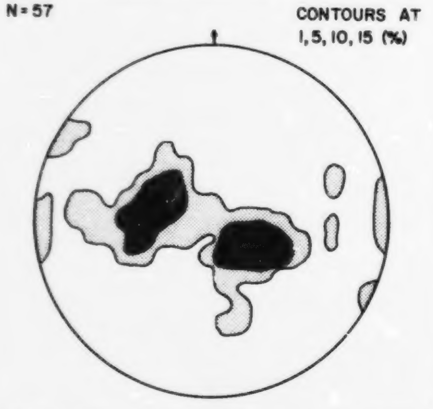
KI: DYKES AND VEINS 5


N=67
CONTOURS AT
1, 3, 5, 7, 10, (%)

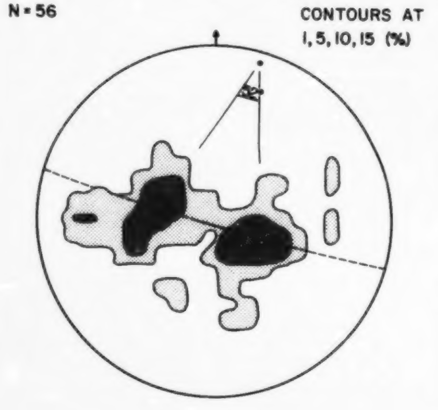
KII: F_3 FOLD AXES AND LINEAR STRUCTURES 6


N=51
CONTOURS AT
1, 3, 5, 10, 12 (%)
68°

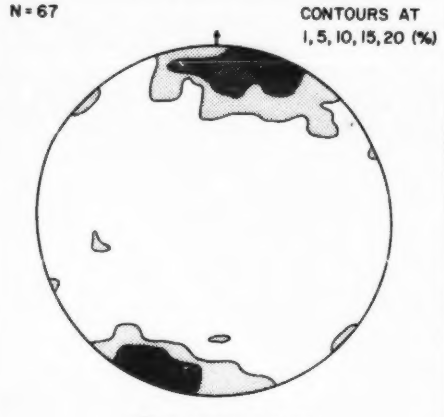
KIII: F_3 FOLD AXES 7


N=57
CONTOURS AT
1, 5, 10, 15 (%)

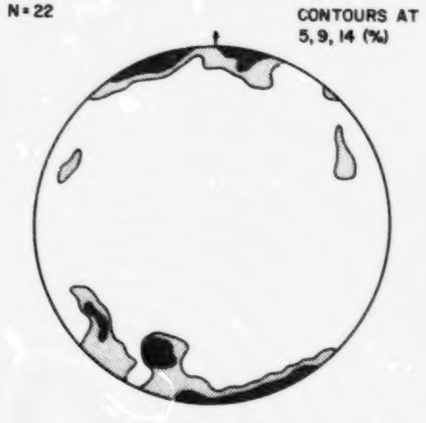
KV: F_3 FOLD AXES AND LINEAR STRUCTURES 8


N=56
CONTOURS AT
1, 5, 10, 15 (%)
52°

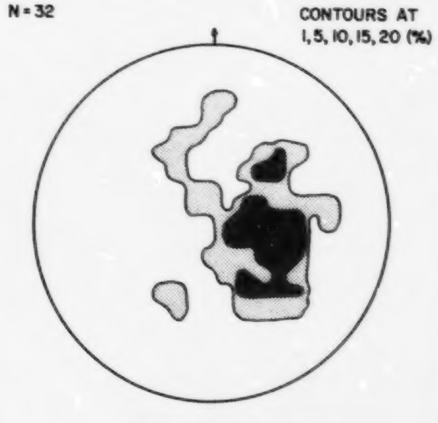
KV: F_3 FOLD AXES 9


N=67
CONTOURS AT
1, 5, 10, 15, 20 (%)

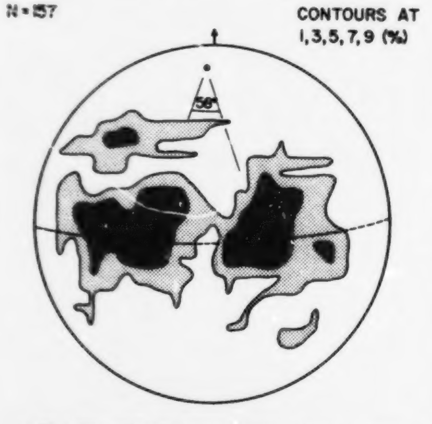
KV: F_3 AXIAL PLANES 10


N=22
CONTOURS AT
5, 9, 14 (%)

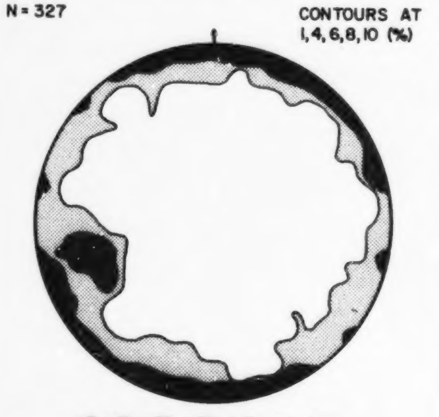
GII: FAULTS 11


N=32
CONTOURS AT
1, 5, 10, 15, 20 (%)

GV: F_3 FOLD AXES 12


N=157
CONTOURS AT
1, 3, 5, 7, 9 (%)
58°

KIII, KIV, KV, KVI AND KVII: F_3 FOLD AXES 13


N=327
CONTOURS AT
1, 4, 6, 8, 10 (%)

GI, GII, GIII, GIV, GV AND GVI:
FAULTS, DYKES AND VEINS 14

STEREOGRAPHIC PROJECTIONS OF STRUCTURAL ELEMENTS. DIAGRAMS ARE CONTOURED BY PERCENTAGE OF POINTS PER ONE PER CENT AREA.
KI, GII ETC REFER TO STRUCTURAL DOMAINS SHOWN IN FIGURE 19.

SYMBOLS

N = NUMBER OF POINTS

• 52° F_4 FOLD AXIS AND APPROXIMATE AXIAL ANGLE DETERMINED FROM DISTRIBUTION OF F_3 FOLDS.

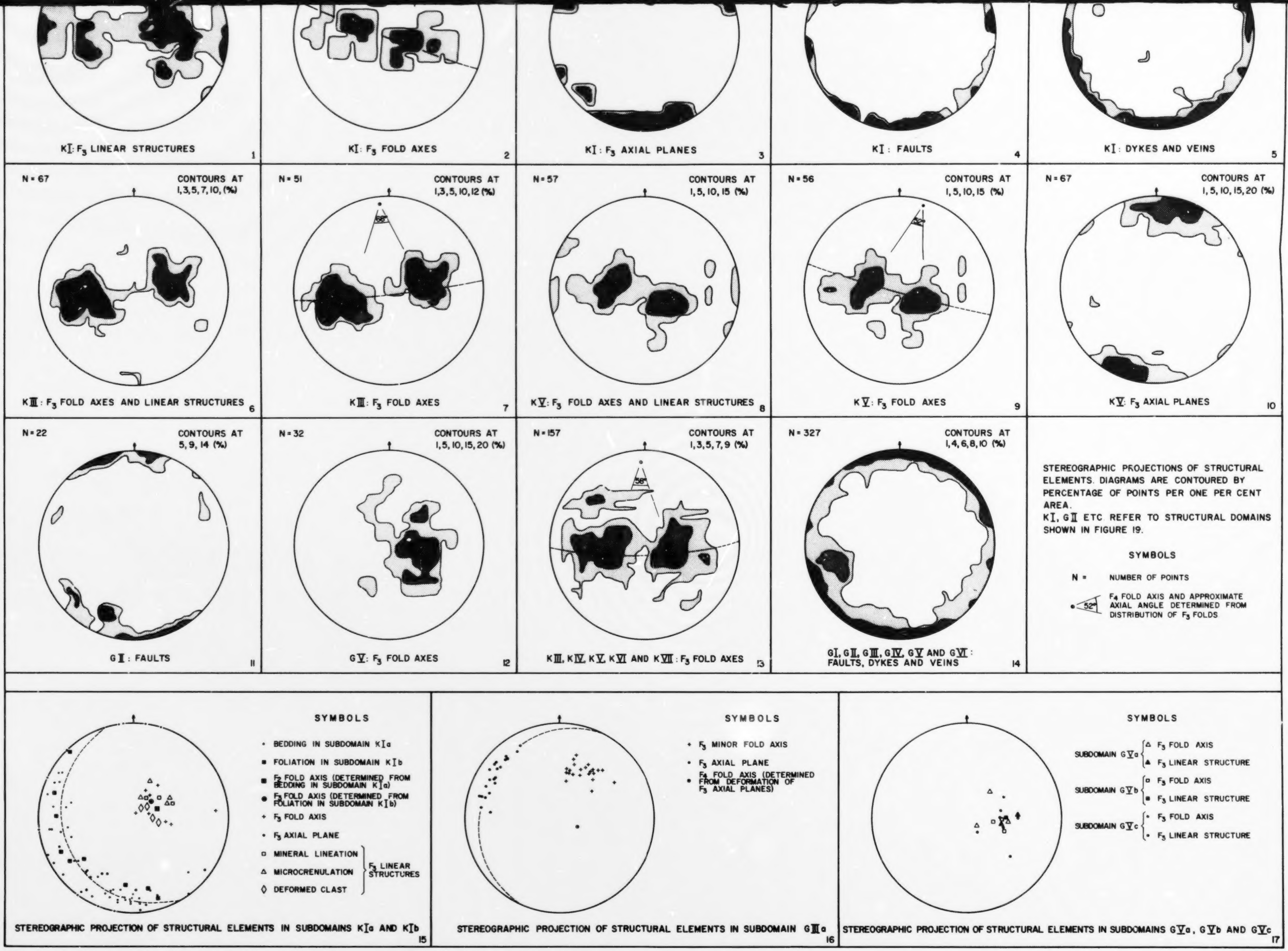


Figure 18: Stereographic projections of structural elements; structural domains are shown in Fig. 19.